PHONOLOGICAL SYSTEMS AND INTELLIGIBILITY OF MANDARIN-SPEAKING 4-YEARS OLDS IN TAIWAN

A Dissertation by

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DEDICATION

To my parents, my sister,

my brother, and my dear friends

Get wisdom…though it costs all your possessions,
get understanding.

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ABSTRACT

The goal of this research project was to investigate speech productions (deviations/patterns) of two groups of Taiwanese-Mandarin-speaking 4-year olds. The primary purpose was to determine which, if any, of the following variables predict the criterion variable, intelligibility (Percentage of Intelligible Words [PIW]): (a) Total Occurrences of Major Phonological Deviations (TOMPD), (b) Percentages of Consonants Correct (PCC), and (c) Mean Lengths of Response (MLR). The second major purpose was to determine and compare the performances of the two groups of 4-years olds: (a) typically developing (TD) children, and (b) children with speech sound disorders (SSD).

All participants were assessed individually, and their speech was recorded during the assessment. Next, a receptive language test was administered. The co-investigator then showed each child some toys and then played with him/her. The speech samples were transcribed and analyzed.

The results indicated that only one variable predicted intelligibility as a result of the regression model. Phonological deviations accounted for 74% of the variance (T=-7.062, p=.000). A t-test was used to examine differences between the means of the two groups. Consonant sequence omissions, liquid deficiencies, nasal deficiencies, and strident deficiencies occurred most frequently. All of the Major Phonological Deviations occurred in the speech productions of children with SSD.

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CHAPTER I

INTRODUCTION

Spoken language is the ability to express an individual's opinions, to share feelings, and to interact with others via sounds. Producing sounds appropriately and accurately is a complicated process. Notwithstanding, it is the most efficient communication method for human beings. That is, individuals simultaneously produce sounds and articulate specific phonemes and syllables aligned with certain linguistic rules to communicate messages. Listeners hear and interpret signals in order to achieve a message exchange (Bernthal, Bankson & Flipsen, 2013).

Speech sound productions involve complex procedures. Individuals produce sounds or phonemes through the coordination of respiration, articulation, and resonance. If any of these are problematic, speech may be difficult to understand. Children may have difficulty expressing themselves or communicating with others.

In addition, research has indicated that children with speech sound disorders (SSD) often have difficulty processing linguistic information, understanding social communication, and may also have lowered self-confidence (Anderson & Antonak, 1992; Lof, 2012; Silverman & Paulus, 1989). Children with SSD may struggle, not only in academic performance, but also in social interactions at school (e.g., Anderson & Antonak, 1992; Felsenfeld, 1992). Additionally, results of several studies indicated that severity of speech impairments may be important predictors of phonological awareness problems which impact later literacy (Holm, Crosbie, & Dodd, 2007; Rvachew, 2007; Stackhouse & Wells, 1997).

Early intervention has led to better outcomes in later academic performance and behaviors (e.g., Majnemer, 1998; Smith, 1988; Spencer, Goldstein, Sherman, Noe, Tabbah, Ziolkowski, & Schneider, 2012). That is, children with speech difficulties benefit from early intervention.

Lof (2012) reported that in the United States, 10% of the preschool and school-age children have speech sound disorders. Campbell, Dollaghan, Rockette, Paradise, Feldman, Shriberg, Sabo, and Kurs-Lasky (2003) reported that approximately 15% of American 3-year-old children have SSD. Shriberg, Toblin, and McSweeny (1999) found that 3.8% of 6-year-old children still have speech difficulties. Many preschool children recover from SSD during intervention and as they mature. On the other hand, 91% of speech-language pathologists (SLPs) in schools reported that their caseloads consisted mainly of students with "articulation" or "phonological" disorders (ASHA, 2006). Even though most preschool children correct speech production difficulties after intervention, some continue having difficulties during school years, especially those with severe/profound SSD.

A number of studies have been conducted in English to investigate acquisition of speech sounds, phonological development, and the effects of intervention (Goldstein, 1995; Hodson & Paden, 1991; Kemper, 1996; Mann & Hodson, 1994; Oller, 1980; Ruder & Bunce, 1981; Stoel-Gammon & Dunn, 1985; Stoel-Gammon, 1992). The purposes of the studies were to obtain information about typically developing (TD) children and to identify better ways to improve children's speech sound productions. Although results and methodologies differed, results provided some similar information regarding speech intervention. For example, children's phoneme inventories increased between the age of 1.5 and 4 years. Most children acquired adult-like speech by age 4 years (Creaghead & Secord, 1989). The results provided a broad blueprint for understanding phonological development. On the other hand, differing results have caused confusion when considering whether a child's speech was delayed or not.

Results have indicated that intervention focusing on phonological deviations/patterns is an efficient method for assisting children with highly unintelligible speech (Hodson, 2010; Hodson & Paden, 1991; Kemper, 1996; Ruder & Bunce, 1981). Phonological treatment approaches are based on the analyses of the sound productions and patterns. The rationale is that speech sound productions are acquired via a systematic framework (i.e., phonology). Therefore, when children have many error sounds, the most efficient treatment method involves working on phonological patterns rather than individual phonemes. Information regarding phonological deviations that are related to intelligibility of continuous speech is a critical need, not only for diagnoses, but also for intervention.

Previous studies regarding phonological deviations of TD children and children with SSD have been reported for English (e.g., Dyson & Paden, 1983; Grunwell, 1987; Hodson & Paden, 1991; Stoel-Gammon; 1985; Watson & Scukanec, 1994). For example, Hodson (1997) reviewed phonological development studies and developed seven stages of phonological development from birth to adult. Some similarities have been observed regarding phonological deviations among different languages (Crystal, 1997); some differences exist regarding the nature of languages (e.g., To, Cheung, & McLeod, 2011; Topbas, 2006), but phonological studies for other languages are limited. For example, there is a paucity of research pertaining to phonological patterns/deviations for Taiwanese-Mandarin-speaking children (e.g., Jeng, 2011). In addition, few studies have been conducted to investigate intelligibility in continuous-speech utterances of preschoolers. A need exists to investigate major phonological patterns/deviations that predict speech intelligibility in TD children and children with SSD who speak Taiwanese Mandarin.

Because intelligibility is a way to assess communication effectiveness, an investigation of variables that predict intelligibility may have merit for clinical purposes. For example, phonological patterns have been found to provide a direction for intervention (Hodson, 2010). Studies have shown that Total Occurrences of Major Phonological Deviations (TOMPD) have been found to predict intelligibility of speech samples for English-speaking children (Magnus, Hodson, & Schommer-Aikins, 2011) and also for bilingual English-Spanish-speaking children (Prezas, Hodson, & Schommer-Aikins, 2012). Information about intelligibility of speech in Mandarin-speaking-children, however, is lacking.

Statement of the Problem

Speech productions play a paramount role in early stages of 4-year-old children's development. Investigating intelligibility is a first step for both research and clinical purposes. Studies of Mandarin-speaking children, however, are lacking.

Most reference information used in Taiwan currently is based either on the studies in English or subjective judgments. Some clinicians use Percentages of Consonants Correct (PCC; Shriberg & Kwiatkowski, 1982) as the major determiner of severity for children's speech difficulties. Further investigation is needed to determine whether PCC is an optimal method for clinical purposes.

In addition, the common method for SSD diagnoses is to score sound productions as totally accurate or totally inaccurate. This method overlooks differences among error sounds. For example, distortions and omissions are scored as equal even though they have different impacts on speech intelligibility. It is necessary to investigate factors associated with intelligibility for different languages, including Taiwanese-Mandarin-speaking children, in order to determine optimal goals for speech intervention.

Purpose of the Study

This study was designed to investigate speech productions (deviations/patterns) of two groups of Taiwanese-Mandarin-speaking 4-year olds. The primary purpose was to determine which, if any, of the following variables predict the criterion variable, intelligibility (Percentage of Intelligible Words [PIW]): (a) Total Occurrences of Major Phonological Deviations (TOMPD), (b) Percentages of Consonants Correct (PCC), (c) Mean Lengths of Response (MLR). The second major purpose was to determine and compare the performances of the two groups of 4-years olds: (a) TD children, and (b) children with SSD.

CHAPTER II

REVIEW OF THE LITERATURE

Speech is paramount to communicate in the daily life. Cross-language studies related to speech have been investigated for decades (e.g., Dodd, Holm & Li, 1997; Hua & Dodd, 2000; Nielsen & Dau, 2009; So & Dodd, 1994; Yavas & Goldstein, 1998). Studies showed that only broadly developmental patterns could be described as universal (e.g., Dodd, Holm & Li, 1997; Goldstein, 1995; Ingram, 2004). Phonemic and phonological inventories, however, differ in terms of phonemes and word structure in different languages (e.g., To, Cheung & McLeod, 2013; Topbas, 2006).

Typically developing children acquire speech sounds and word structure of the language during early childhood. Speech sound development is relatively sequential with some sounds developing earlier than others. Some children, however, have trouble in developing the speech sounds. Studies have been conducted to analyze these error sound productions and phonological systems in English (e.g., Hodson, Chin, Redmond, & Simpson, 1983; To, Cheung & McLeod, 2013; Topbas, 2006). Studies of phonological deviations in Mandarin, however, are few.

Intelligibility is considered to be a direct index of an individual's communication (Kent, 1992). Researchers evaluated speech intelligibility, in order to assess communication efficiency, as well as the potential factors of intelligibility. In depth- studies related to what predicts intelligibility have been reported in English (e.g., Magnus, Hodson, & Schommer-Aikins, 2011; Prezas, Hodson, & Schommer-Aikins, 2012), but studies related to intelligibility in the Mandarin language are lacking.

In this chapter, the development of typical and atypical speech sounds in English and Mandarin will be discussed. Next, intelligibility: the definition, the measurement, and the studies in English and Mandarin, will be addressed. In the fourth section, various methods of speech assessment, English and Mandarin, are presented. Then, the differences between Mandarin phonemes which include consonants, vowels, and tones, are presented. Finally, the results of the pilot study are presented.

Stages of Typical Speech Sound

Research has indicated that broad developmental sequences can be described as universal (e.g., Dodd, Holm, & Wei, 1997; Goldstein, 1995; Ingram, 2004). Babies start to communicate via crying since they are born. They listen to sounds in their environment and imitate those sounds to approximate the adult sound system. Researchers investigated the development of sounds in different studies (e.g., Robb & Bleile, 1994; Stoel-Gammon & Gunn, 1985) and concluded six stages as follows:

Stage 1. Prelinguistic stage (0:1-1:0): During this stage, children explore and perceive a variety of sounds. Children produce reflexive and non-reflexive vocalization, and begin to produce some vocalization sounds. Nathani, Ertmer, & Stark (2006) and Oller (1980) further divided the pre-linguistic intentional stage of acquisition into four stages: a. Reflexive Vocalization (0:0-0:2; year: months): crying and reflexive sounds appear in this stage. b. Control of Phonation (0:2-0:4). Some consonant-like and vowel-like sounds are found. c. Expansion and Babbling (0:4-0:9). Babies start to do vocal play and have some irregular-timed consonant-vowel (CV) syllables, canonical babbling. d. Variegated Babbling (0:10-1:0). Babies start to produce more CV syllables with different consonants and vowels. Also, adult-like prosody occurs.

<u>Stage 2</u>. First words stage (1:0-1:6): Children begin to produce meaningful speech sounds and produce simple syllable structures, such as consonant-vowel (CV), CVC, and CVCV. These syllables are presented as whole units rather than individual sounds.

<u>Stage 3</u>. Phonemic development stage (1:6-4:0): During this stage, children begin to produce individual phonemes or sounds rather than whole units. Most phonemic inventories emerge during this period of time. Children produce adult-like speech and have few error sound productions by the age of 4 years. The syllable structures become more complicated, including consonant clusters (e.g., *stop, spot, snow*) and multisyllabic words (e.g., *computer, extraordinary*).

<u>Stage 4</u>. Stabilization of the phonological system (4:0-8:0): Children complete phonetic inventories during this stage. By the age of seven a child's speech is more stable and adult-like. Children are able to produce more difficult words as well as show an improvement of comprehension in targeted phoneme systems during reading and writing.

Hoffman & Norris (1989) investigated the phonological system in a broader way and added two stages to the development of typical children. The two additional stages include the morphophonemic and spelling development:

<u>Stage 5</u>. Morphophonemic development stage (7:0-12:0): Children learn morphophonemic rules reading and writing. Therefore, children continue the development of phonological system even though most of them master the phonetic inventory before the age of 7.

<u>Stage 6</u>. Spelling stage (12:0-16:0+): Children learn and master spelling skills. The phonological and phonemic patterns are reinforced as they spell and write.

The stages listed above are a general sequence. The actual development of phonological systems of typically developing children includes specific developmental timelines according to the researchers.

Development of Phonological Systems in Typically Developing Children

Phonology, a system of speech sounds in a language and the characteristic rules that govern the sounds, is a broader concept than articulation, the placement and manner of speech sound productions. It includes the sounds that differentiate a word's meaning in a language and the adjustment of the same phonemes which occur in different positions of words. Stampe (1973) suggested the "natural phonological process." Additionally, Ingram (1976) suggested that children learn speech sounds in a linguistic structure. This finding provided another way to investigate speech sound development and to categorize speech sound disorders.

Studies listed in Table1 have investigated the development of phonological systems (e.g, Dyson & Paden, 1983; Haelsig & Madison, 1986; Stoel-Gammon; 1985). Previous studies have utilized longitudinal methods and cross-section method (Table 1).

TABLE 1

DEVELOPMENT OF ENGLISH PHONOLOGICAL SYSTEM

Age	Dyson & Paden (1983) 2:0	Stoel-Gammon (1985)	Haelsig & Madison (1986) 3:0-5:0	Grunwell (1987) 2:0-5:0	Preisser, Hodson, & Paden (1988)	Watson & Scukanec (1994) 2:0-3:0
<2:0					Consonant reductions Liquid deficiencies	
2:0	Gliding Cluster reduction Fronting Stopping Final consonant deletions	Voiced Anterior Stops Nasals Glides		Weak syllable deletions Final consonant deletions Doubling Consonant assimilations Cluster reduction Stopping		Liquids simplification Vowelization Cluster reduction Stopping
2:5				Weak syllable deletions Final consonant deletions Consonant assimilation Cluster reduction Stopping		Liquids simplification Vowelization Cluster reduction Stopping
3:0			Consonant cluster reductions Weak syllable omissions Gliding Bilabial assimilation Liquids	Weak syllable deletions Final consonant deletions Cluster reduction Stopping		Cluster reduction Stopping
3:5			Consonant cluster reductions Weak syllable omissions Gliding Bilabial assimilation Liquids	Weak syllable deletions Final consonant deletions Cluster reduction Stopping		

TABLE 1 (continued)

4:0		Consonant cluster reductions Weak syllable omissions Gliding Bilabial assimilation Liquids	Weak syllable deletions Stopping
4:5		Weak syllable omissions Consonant cluster reductions	Stopping
5:0		Weak syllable omissions Consonant cluster reductions	Stopping

Results showed some similarities among several studies (Dyson & Paden, 1983; Grunwell, 1987; Haelsig & Madison, 1986; Preisser, Hodson, & Paden, 1988; Stoel-Gammon, 1985; Watson & Scukanec, 1994). Consonant cluster reductions (e.g., stop→ /top/), stopping (e.g., some→ /tom/), gliding (e.g., rock→ /wɑk/) and final consonant deletion (mop→ /mɑ/) are found in typically developing children between ages 2 and 3 (e.g., Dyson & Paden, 1983; Grunwell, 1987). By the age of 3, consonant cluster reductions and final consonant deletions are rare. By the age of 4, weak syllable deletion (e.g., chocolate → /tʃalɪt/) is still observed (Grunwell, 1987; Haelsig & Madison, 1986). Weak syllable deletion is often demonstrated by adults.

Some phonological deviations result because of the influence of other sounds in the word, such as consonant assimilation (boat→ /bop/), doubling (e.g., table→ /tata/), and nasals (e.g., papa→/mama/) reported in 2-year-old children (Stoel-Gammon, 1985; Stoel-Gammon, 1985; Watson & Scukanec, 1994). Assimilation and stopping were found by the children between 2 and 3 (Grunwell, 1987; Haelsig & Madison, 1986). In some studies, certain phonological deviations, such as consonant cluster reductions, stopping, and gliding continued through the age of 5 (Haelsig & Madison, 1986).

Although results showed some differences, most of the phonological deviations were gradually reduced as children grew up. For example, phonological patterns, such as final consonant deletion were rare in children by the age of 4. Understanding the phonological deviations at different ages could provide a better blueprint for children's speech sound development.

Hodson (1997) assembled results of phonological development from several studies (e.g., Dyson and Paden, 1983; Grunwell, 1981; Hodson & Paden, 1981; Oller, 1980) and provided seven steps of typical phonological acquisition. They comprise (a) children have canonical babbling and first words by the end of the first year. (b) children have some expressive words and CV structures by age 1.5 years. Their phonological patterns include stops, nasals, and glides. (c) Children use syllableness (ie., more than one syllable by 2 years). They communicate with words. Their phonological patterns contain final consonants. (d) Children expand their phonemic inventories by age 3 years. The phonological patterns consist of /s/ clusters (e.g., *stop*, *swim*), anterior-posterior contrasts (e.g., *cat*, *car*). (e) Children have adult-like speech by 4 years of age. Omissions are rare by this stage. Also, most simplifications have disappeared. (f) Children have stable phonemes. Liquids /l/ is gradually mastered by age 5 years, and /r/ is mastered by most 6 year olds. (g) Children appear to have adult standard speech by 7 years of age. Sibilants and the "th" phoneme are proficient.

Some children, however, do not follow these developmental sequences. They may face communication problems after they learn how to interact with others by words. Phonologists investigated various participants, methods, and relevant factors to have a better understanding of children's development.

Studies of Children with Speech Sound Disorders

Because of the importance of speech in communication, many investigators focused on evaluating heterogeneous groups of children with speech sound disorders through many decades. Some were investigated in pre-linguistic stages; some were preschoolers; and others were teenagers. Some investigated speech intelligibility (e.g., Kipfmueller & Prins, 1971; Metz, Samar, Schiavetti, Sitler & Whitehead, 1985), some studied percentages of consonant correct (e.g., Morrison & Shriberg; Prather & Hedrick, 1975), and some analyzed phonological patterns (e.g., Hodson, Chin, Redmond, & Simpson, 1983; Magnus, Hodson, & Schommer-Aikins, 2011).

Additionally, some research related to speech sound disorders with atypical anatomy was conducted (e.g., Chin, Tsai, & Gao, 2003; Flipsen & Colvard, 2006; Hodson, Chin, Redmond, & Simpson, 1983; Kent & Vorperian, 2013; Osberger, Maso & Sam, 1993 1993); however, participants with speech sound disorders had no anatomy concerns (e.g., McLeod, Harrison, McAllister, & McCormack, 2013). Children with atypical anatomy were mainly participants to test while considering speech develops. These participants included children with hearing loss, children with repaired cleft palates, Down syndrome, neurological disorders, and intellectual disorders.

Chin, Tsai, and Gao (2003) investigated connected speech productions of children with and without cochlear implants. The results indicated that children with cochlear implants had better outcomes as the chronological age and duration of cochlear implant use gradually increased. However, the adult-like speech was not found in young children with cochlear implants. Noordhoff et al., (2004) investigated development of articulation from 115 preschoolers with and without cleft palates. The results showed that 5-year-old children with cleft palates had poorer articulation scores than typically developing 2-year olds.

Flipsen and Colvard (2006) investigated speech productions of children with cochlear implants in conversational speech samples. The results indicated that speech productions of the participants with cochlear implants was better than those using hearing aids in the previous research (Kyle, 1977; Monsen, 1978), but was not as good as peers with normal hearing.

Kent and Vorperian (2013) reviewed articles that investigated speech production characteristics by children and adults with Down syndrome. They found that speech issues in Down syndrome were complicated because of the combination of articulation, phonology, fluency, prosody, and intelligibility. Several studies reported that speech intelligibility in Down syndrome was poor and may last through adulthood (Buckley, 2000; Chapman et al., 1998; Chapman & Hesketh, 2000; Horstmeier, 1988; Miller & Leddy, 1999, Rosin & Swift, 1999; Stoel-Gammon, 2001; Swift & Rosin, 1990; Van Bysterveldt, 2009).

Children with neurological disorders, such as cerebral palsy, pediatric traumatic brain injury (TBI), and multiple disabilities, may have complex communication problems (Campbell, Dollaghan, Janosky, Rusiewicz, Small, Dick, Vick, &Adelson, 2012; Forrest, 2003; Hustad, Schueler, Schultz & DuHadway, 2012; Wilson & Arnott, 2013). Communication problems include poor speech, severe voice and prosody deficits, language problems, and reading problems (Cahill, Murdoch & Theodoros, 2005; Catroppa, Anderson, Muscara, Morse, Haritou, Rosenfeld et al., 2009).

On the other hand, phonological deviations were found in studies that investigated speech samples of children with atypical anatomy. For example, Hodson, et al., (1983) investigated phonological deviation and intervention in one 5-year-old child with a repaired cleft. Several phonological deviations, including singleton obstruent omissions, velar deviations, cluster reductions, stridency deletions, liquid deviations, and glottal replacements, were found.

Noordhoff et al. (2004) investigated the development of articulation for 115 preschoolers with and without cleft palates. They concluded that substitutions were the most common error type and that children with delayed palateplasty for cleft palates performed more poorly in articulation scores compared to typically developing children.

Whitehill and Chau (2004) used single-word tests to examine speech productions in 15 Cantonese speakers with repaired cleft palates. The major contrasts included fronting and backing, stops and nasals, stops and fricatives, and stops and affricates.

McLeod et al., (2013) investigated nonclinical preschoolers who had been identified by parents or teachers as having speech problems. The results indicated that common phonological deviations included fricative simplification (82.5%), cluster simplification (49.0%), cluster reduction (19.6%), gliding (41.3%), palatal fronting (15.4%), interdental lisps on /s/ and /z/ (39.9%), dentalization of other sibilants (17.5%), and lateral lisps (13.3%).

Preston and Edwards (2010) investigated error sounds of 4 and 5- year olds. They found that preschoolers produce speech sound errors which included problems in higher level phonological representations as well as the lower level motoric problems.

Macrae and Tyler (2014) compared the speech errors between preschoolers with concurrent language problems and speech difficulties with those who only evidenced speech sound disorders. They found that children with concurrent language problems and speech difficulties had more omissions and fewer distortions.

Further research with larger sample sizes comparing children who are typically developing with children who have intelligibility difficulties is needed. Additionally, the studies comparing the relationships between intelligibility and phonological patterns are needed. One study reported the use of intelligibility ratings and phonological deviations (Magnus et al., 2011).

The investigator collected speech samples from 50 children ages 3- to 5-years. The *Assessment of Phonological Process-Revised* (APP-R; Hodson, 1986) and a continuous speech sample were recorded and used for a listener rating procedure. The results of this study suggested that phonological deviation average, mean lengths of response, hyper-nasality, hearing status and anomaly type were predictive variables.

Studies of Speech Sound Disorders in the Mandarin Language

Although the development of phonemic and phonological systems in English and in Spanish have been studied in the United States (e.g., Goldstein, 1995; Hodson & Paden, 1991; Mann & Hodson, 1994), studies in Mandarin are lacking (e.g., Hua & Dodd, 2000).

Young, Lai, and Liao (1984) investigated speech samples of 146 Mandarin-speaking participants (96 male; 50 female) over the age of 4 who had articulation disorders. They concluded that the most frequent sound error was /s/, followed by /z/. No tonal errors were found in this study. Fricative and affricate deficiencies were most common, followed by stopping. Substitutions and omissions were frequent, while distortions were rare. Final consonant omissions were rare; however, 27.4% of the participants evidenced nasal deficiency.

Young, Lai, and Liao (1985) investigated types of sound errors of 74 Mandarin-speaking children with articulation disorders (57 males; 17 females) between the ages of 4 and 23 years. They concluded that substitution errors were the most common, followed by omissions. Distortions were rare. Unaspirated sounds were substituted for aspirated and stops were substituted for fricatives. It was rare that nasal omissions were found both in the initial position and that the phoneme /l/ substituted for /z/. It was also a rarity that bilabials were substituted for other articulation placements. However, phoneme /t/, /t^h/, /k/, and /k^h/ were frequently substituted phonemes.

Jeng (2011) investigated phonological deviations of sound error productions of 55 Taiwanese, Mandarin-speaking preschool children between the ages of 5 and 6 years. In typically developing children, participants were divided into six groups of children: ages 2.5-, 3.0-, 3.5-, 4-, 5-, and 6-year-old. Speech samples were collected via a picture naming task. Thirty-two words collected from speech samples were chosen to elicit speech productions in this study. The results were compared to those of typically developing children. Jeng concluded that significant differences in occurrence of phonological deviations were found between typically developing children and children with speech sound disorders. Additionally, similar patterns were found in two groups. That is, children with speech sound disorders demonstrated delays in patterns of phonological deviations.

In conclusion, more studies are needed to provide information about children speaking Mandarin. Additionally, previous research has investigated errors and analyzed the phonological deviations in children with speech sound disorders; however, the results did not mention omissions in children's speech productions. Finally, research studies investigating relationships between intelligibility and phonological deviations are needed.

Definition of Intelligibility

Intelligibility has been defined as the degree to which others can understand an individual's speech (Gordon-Brannan, 1994; Hodson, 2010). It is also described as "the most practical measurement of oral communication competence" (Metz, Samar, Schiavetti, Sitler, & Whitehead, 1985, p1). Kent (1992) suggested that speech intelligibility is the "behavioral standard of communication" and declared that intelligibility is a direct understanding of an individual's communication.

Speech intelligibility includes several elements: (1) auditory perception, (2) linguistic, (3) acoustic, and (4) physiologic (Kent, 1992). Any deviation of these four elements has the potential to lead to communication problems. For typically developing preschoolers, the intelligibility of their speech is not perfect because immature linguistic development. For preschoolers with speech sound disorders, however, their speech may be highly unintelligible.

Speech intelligibility is one important clinical factor of assessment although estimating individuals' speech intelligibility is not an easy task. For example, Hodson (2010) recommended that the percentage of intelligibility in a conversational speech sample could be used to compare the progress of the intervention over time. Also, Shriberg and Kwiatkowski (1982) concluded that speech intelligibility is one paramount factor used by the speech-language pathologists and communication partners to decide the severity of phonological problems. Additionally, intelligibility is frequently taken as an index of intervention improvement (Hodson, 2010).

Measurement of Intelligibility

Intelligibility measurements have been assessed in different ways (Kipfmueller & Prins, 1971; Marquardt & Saxman, 1972; Weiner, 1967). Some studies investigated intelligibility via subjective interval ratings by listeners (e.g., Weiss, 1982; McGarr, 1983); and some individuals were examined by objective counting of intelligible words (e.g., Shriberg & Kwiatkowski, 1980; Shriberg, 1986).

Schiavetti (1992) commented on two measuring tools: rating scales and counting all intelligible words. Rating scales are frequently utilized because they provide fast and easy ways to estimate intelligibility. The counting method is not used as often as the rating scales because the methodology is more complex and intelligible words may take a long time to transcribe.

Measuring methods can be divided into several aspects: (a) variety of speech samples, such as consonants, words, sentences, and connected sentences; (b) the way speech sample are elicited, (e.g., picture-naming, sentence repetition, spontaneous conversation, and narration) either by story retelling or telling the story from a wordless storybook (e.g., Flipsen & Colvard ,2006; Khwaileh & Flipsen, 2010; Whitehill & Chau, 2004; Willadsen & Poulsen , 2012); (c) evaluation of speech samples, (e.g., writing intelligible words, multiple choice, and subjective ratings) (e.g., Bernthal, Bankson & Flipsen, 2013; Gordon-Brannan & Weiss, 2004).

Asking unfamiliar listeners to write all words they can understand is a common method for measuring speech intelligibility. McGarr (1983) examined the speech intelligibility of deaf speakers in an open-set response format between experienced and inexperienced listeners. Twenty participants between 8 and 15 years of age were asked to produce sentences and words. In four speech conditions, 120 listeners wrote down what they heard. The results indicated that no statistically significant differences existed between experienced and inexperienced listeners.

Additionally, Osberger, Maso and Sam, (1993) examined the speech intelligibility of children with cochlear implants, tactile aids, and hearing aids. The speech samples, which included 10 sentences read by the participants, were written down by three listeners unfamiliar with the content of the sample to count the percentages of intelligibility.

Chin, Tsai, and Gao (2003) also investigated connected speech intelligibility of children with and without cochlear implants. The *Beginners' Intelligibility* Test (BIT; Osberger, Robbins, Todd, & Riley, 1994) was used to calculate the percentages of correct words. The speech intelligibility of each participant was obtained by three listeners, unfamiliar with the sample who listened to the recording files and wrote down the words they understood.

Different methods of calculating speech intelligibility have been used. For example, Monsen (1983) investigated interaction between speech intelligibility and other related factors. Forty-four listeners wrote down as many words as they heard, while listening to recorded speech samples. Content words were assigned a higher percentage of the total score and function words (e.g., the, on~ of) were assigned lower values. Weighted systems, however, have not been used recently.

Collecting speech samples at the word level is a frequently used method to assess intelligibility among various groups of children. For example, Willadsen and Poulsen (2012) investigated a cross-sectional study of children with repaired cleft palates, as well as typically-developing children. Picture-naming tasks were administrated to 84 unfamiliar listeners.

Words and connected speech samples have occasionally been selected for speech intelligibility. For example, the *Weiss Intelligibility Test* (Weiss, 1982) is an assessment to determine intelligibility of 25 single words and a continuous-speech sample of 200 words for children and adolescents. Unfamiliar listeners wrote down all words they understood, and intelligibility was calculated.

Another method involves counting percentages of intelligibility (PIW), which is obtained by dividing the number of intelligible words by the number of whole words in a continuous speech sample, and then multiplied by 100. The intelligible words were written by three unfamiliar listeners and compared to each other (Gordon-Brannan & Hodson, 2000; Kent, et al., 1994; Kwiatkowski & Shriberg, 1992).

Studies of Intelligibility in the English Language

Studies of speech intelligibility have shown similar results in typically developing children. Coplan and Gleason (1988) suggested that normal acquisition of intelligibility is typically achieved by the age of 4 years. They also indicated that speech improvement is a gradual process, and children's speech could be understood by unfamiliar listeners up to 50% by the age of 2 years, 75% by the age of 3, and 100% by the age of four. Also, Willadsen and Poulsen (2012) compared speech intelligibility of 3-year-old typically developing children and children with repaired cleft palates at either 12 or 36 months.

Willadsen and colleagues found that the intelligibility of typically developing children was 76%.

On the other hand, studies of speech intelligibility for children with speech sound disorders have been reported. Whitehill and Chau (2004) used single-word tests to examine intelligibility in 15 Cantonese speakers with repaired cleft palates. The test is a multiple-choice format, including 13 phonetic contrasts. Whitehill and Chau concluded that intelligibility scores ranged from 32.3% to 86.7%. Flipsen and Colvard (2006) investigated speech intelligibility of children with cochlear implants in conversational speech samples. They followed six children who had cochlear implants for periods of 12 to 21 months. Intelligibility was obtained using an utterance-by-utterance approach and a whole sample approach. Their results indicated that speech intelligibility of the participants was better than those using hearing aids in the previous research (Kyle, 1977; Monsen, 1978), but was not as good as normal hearing peers. Additionally, a significant correlation was found between the two measure approaches. Also, significant correlations were reported among chronological age, hearing age, and post-implantation age.

Single word and sentence intelligibility of children with cochlear implants has been examined (Khwaileh & Flipsen, 2010). Seventeen children, ages from 4 to 11 years with cochlear implants participated in this study. *The Children's Speech Intelligibility Measure* (CSIM; Wilcox & Morrris, 1999) and *the Beginners' Intelligibility Test* (BIT; Osberger, Robbins, Todd, & Riley, 1994) were used to assess speech intelligibility. CSIM transcription (CSIM-T), CSIM multiple choice (CSIM-MC), and BIT were analyzed. Results indicated that intelligibility on the CSIM-T ranged from 1 to 77%; intelligibility on the CSIM-MC ranged from 33 to 89%, and intelligibility on the BIT ranged from 9 to 97%.

Willadsen and Poulsen (2012) looked at the differences of speech intelligibility in three groups of children 3 year-olds: typically developing children and children with repaired cleft palates at either 12 months or 36 months. They found that speech intelligibility of children with unrepaired hard palates was is much poorer compared to those with repaired hard palates and typically developing children.

Monsen (1983) investigated interaction between speech intelligibility and related factors, such as phonologic, syllabic, and syntactic structure of the language spoken, the visibility between the communicators, and the contextual situation. Ten subjects between 7; 0 and 15; 0 years of age with hearing-impairments participated in this study. The result indicated that the average percentage of intelligibility for all participants was 79% with a range of 57% to 96%. Additionally, Monsen concluded that the speech intelligibility varied due to multiple factors, such as the content of speech, the individual listeners, and situational context.

Studies of intelligibility in the Mandarin Language

The intelligibility of speakers of Mandarin has not been investigated as frequently as it has been studied in English. Studies of intelligibility in Mandarin-speaking children with speech sound disorders are also limited (e.g., Chin, Tsai, & Gao, 2003). Hua and Dodd (2000) investigated 33 Putonghua (modern standard Chinese)-speaking children with speech sound disorders. They used picture-naming tasks via 44 pictures of items or actions and picture-describing tasks to measure children's speech. Eight quantitative and qualitative measures, including percentages of consonants wrong (PCW), total number of phonological processes used, total number of missing phones in phonetic inventory, Z-scores, phonetic inventory, phonemic inventory, phonological processes, and inconsistency ratings were analyzed. The results indicated that phonological patterns matched the system of language learning in English. Means (standard deviations) of PCW by the age of 2 was 37.1%, by the age of 3 was 19.0%, and by the age of 4 was 10.5%.

Chen (2011) compared the intelligibility of 9 typically developing children and 16 children with speech sound disorders that resulted from hearing loss, Down syndrome, or speech sound disorders of unknown origins. Chen used a wordless book to collect speech samples and asked three unfamiliar listeners to write down the intelligible words they heard in each sample.

Percentages of intelligibility (PIW) were obtained by dividing the total number of intelligible words by the total number of possible words and multiplying by 100. The results indicated that the PIW for typically developing children ranged from 88 to 99% intelligible with a mean of 94%; the PIW range for children with Down syndrome was 38-62%, with a mean of 48%; the PIW range for children with hearing loss was 9-96%, with a mean of 57%; and the PIW range of intelligibility for children with speech sound disorders of unknown origin was 23-69%, with a mean of 50%. Intelligibility is an important measurement for speech sound disorders; however, an analysis using listeners, whether trained or naïve is cumbersome for clinical use. Efficient alternative assessment tools are needed.

In the next section, speech assessment tools in both English and Mandarin, will be introduced. These will be discussed to provide more specific information.

Speech Sound Assessment

Assessment of speech sounds is a necessary diagnostic tool for deciding whether there is a speech sound disorder or not. Assessment is paramount for the clinical purpose of diagnosing potential difficulties and setting up an intervention plan.

In the United States, two types of speech sound assessment tools are frequently used in the clinic: articulation assessment tools and phonological pattern assessment tools. Several instruments used in clinical and school settings will be introduced in the following sections.

English Speech Assessment Instrumentation

Arizona Articulation Proficiency Scale—Third Revision (ARIZONA-3). The *ARIZONA-3* (Fudala, 2000) is a standardized articulation assessment tool for children between 18 months and 21 years of age. The ARIZONA-3 includes 42 picture cards to test major English sounds occurring in words as initial consonants, final consonants, consonant clusters, vowels, and diphthongs. The duration of the assessment is between two to ten minutes. Intelligibility descriptions, severity level, percentile rankings, and standardized scores may be determined by this assessment. It also provides a suggested phoneme inventory which authors state is acquired by 90% of children.

In addition, three subtests, including, a word reading task, language screening task, and spontaneous speech task, are included in ARIZONA-3. Word reading is designed for teenagers and adults to read word cards rather than naming the picture cards. A follow-up question was added for each card which could be used to elicit information about children's language ability. In the spontaneous speech task, picture cards may facilitate a continuous speech sample.

Goldman-Fristoe Test of Articulation—Second Edition (G-FTA-2). G-FTA-2 (Goldman & Fristoe, 2000) is an articulation assessment tool for children 2:0 to 21:11 years old. It was standardized on 2,350 children and provided standardized scores, percentiles, test-age equivalents and percentage of passing sounds by age and word position. It not only assesses children's articulation of consonant sounds in words, but also can be used to assess contextual sound-in-sentences and stimulability.

The sound-in-words section contains 34 colorful pictures that are used to elicit speech sounds in the initial, medial, and final position of words. The sound-in-sentences section, spontaneous speech samples can be collected via a story retelling task using a sequence of cards. The stimulability section assesses the child ability to imitate the administrator's model of sound productions of any sound produced incorrectly from the sound-in words section. Duration of the assessment is between five to fifteen minutes.

The internal reliability is between .94 and .96. The test-retest reliability is .98 for initial, medial, and final sounds. The inter-rater reliability for initial, medial, and final sounds is .93, .90, and 90, respectively.

The Photo Articulation Test—Third Edition (PAT-3). PAT-3 (Lippke, Dickey, Selmar, & Soder, 1997) is an assessment tool to test articulation errors in 3- 9 year-old children. It was standardized on over 800 children. PAT-3 includes 72 colorful photographs to collect speech samples via a naming picture task and continuous speech samples. Word-initial, word-middle, and word-final consonant sounds are assessed in this test. Percentile, standard scores, and age equivalents can be determined. The duration of assessment is 20 minutes.

The tester uses the photographs to elicit children's speech sounds by asking question, “What is this?” The sounds are recorded to provide the clinical information about the child’s articulation errors. The criterion-reliability is .85. Internal consistent reliability, re-test reliability, and inter-judging reliability is .80-.90.

Clinical Assessment of Articulation and Phonology—Second Edition (CAAP-2). CAAP-2 (Secord & Donohue, 2013) is a norm-referenced assessment tool for children between 2:6 and 11:11. The examiner administers the exam by showing the picture books and asking children to name the pictures. The sound productions are recorded to obtain the raw scores. It was standardized using 1486 children and provides standard scores, percentile ranks, and age equivalents. It assesses all consonants in word initial and final position, cluster words, and multisyllabic words. There is also a protocol for phonological processes. The duration of assessment is between 15 and 20 minutes. The inter-rater reliability is above .99.

Hodson Assessment of Phonological Patterns—Third Edition (HAPP-3). HAPP-3 (Hodson, 2004) was designed to assess highly unintelligible speech. It can be used for children over 2 years old. Normative data was provided for children between the ages of 3 and 8 years old. Fifty age-appropriate words were chosen to obtain speech productions. Objects or pictures are used to enhance younger children’s interests and elicit internal carry-over productions.

Major phonological deviations, including omissions of syllables, consonants in clusters/sequences, prevocalic, intervocalic, and postvocalic consonant omissions and deficiencies involving liquids, nasals, glides, stridents, velars, anterior and nonstridents are assessed. The Total Occurrences of Major Phonological Deviations (TOMPD) is calculated to determine the severity of the phonological deviations. Severity is based on four categories:

TOMPD between1 and 50 is mild, 51 to100 is moderate, 101 to 150 is severe, and TOMPD over 150 is profound.

Substitutions and other patterns are analyzed using another form. Including glottal stop replacement, stopping, fronting, backing, gliding, vowelization, metathesis, migration, affrication, deaffrication, palatalization, depalatalization, labial assimilation, nasal assimilation, velar assimilation, other assimilation, coalescence, reduplication, vowel deviation, voice epenthesis, other addition, frontal lisp, lateral lisp, other sibilant distortions, and other deviations.

The HAPP-3 kit includes two screening tools: a preschool phonological screening test and a multisyllabic word screening test. These can be administered in less than 5 minutes and provide information for deciding whether further phonological assessment is needed. Content sampling reliability in the Happ-3 is .96. Interscorer reliability is .98.

Mandarin Speech Assessment instrumentation

Few Mandarin speech assessment tools have been published. In Taiwan, one articulation assessment tool has been published. Another assessment tool has been used for research purposes. The details for each will be presented in this section.

The Checklist of Mandarin Pronunciation—Second Edition. The Checklist of Mandarin Pronunciation (Xi, Xu, & Xu, 2004) has been used to diagnose speech sound disorders and determine the types of errors in children between first grade and ninth grade. It is a criterion-referenced test used to find the error sounds in order to design an intervention plan. It includes four parts: an articulation test, voice check, prosody check, and other error description. Forty-five words were chosen to assess children's articulation errors and four wordless stories are used to obtain speech samples to assess children's articulation errors, voice quality, and prosody in continuous speaking. Inter-scorer reliability is .92 and intra-scorer reliability is .94.

Manual of Mandarin Speech Test for Children. Manual of Mandarin Speech Test for Children (Jeng, 2013) is one phonological assessment tool to assess articulatory and phonological ability in children from 2.5 to 8 years of age. It includes five parts: articulation test, sentence imitation test, continuous speech samples, and oral motor function test. Thirty-six words were chosen to assess children's consonant errors. Common phonological deviations, including aspiration, fronting, backing, labialization, stopping, nasalization, affrication, frication, lateralization, and un-retroflection, were found in this test. Retest reliability is .70. Inter-scorer reliability is .87.

Conclusion

In summary, the speech assessment tools which are published in Mandarin are based on the phonemic errors. That is, the results are analyzed in terms of phonemic errors. It may be useful for those who have few error sounds; however, it is not efficient enough for analyzing multiple speech sound error patterns or to make intervention plans for those with highly unintelligible speech. Development of an assessment tool that could predict the speech intelligibility and facilitate efficient treatment planning is an important goal for clinical purposes.

Mandarin Introduction

Mandarin, also called 華語(*Huáyǔ*), is spoken by 94% of the Asian population, and it is part of the Chinese language. Mandarin is the official language in Taiwan; however, it is not the native language for most Taiwanese individuals.

Mandarin is a tonal language. It includes more open syllables (e.g., 貓 mao, 督 tu) than closed syllables (e.g., 安 an, 林 lín). Only two final consonants (n, ŋ) are used.

In Mandarin, speech is differentiated by consonants, vowels, and tones. The Mandarin phonemes consist of 22 consonants and 22 vowels. Consonants will be discussed first, followed by vowels, and finally tone.

Consonants in Mandarin

Each consonant could be described using four terms: placement, manner, voicing, and aspiration. See Table 1 The manner of production includes consonant phonemes which are stops (ㄅ p, ㄆ p^h, ㄉ t, ㄊ t^h, ㄍ k, ㄎ k^h), affricates (ㄐ tɕ, ㄑ tɕ^h, ㄗ ts, ㄘ ts^h, ㄓ tʂ, ㄔ tʂ^h), fricatives (ㄈ f, ㄏ h, ㄙ s, ㄒ ɕ, ㄕ ʂ, ㄖ ʐ), nasals (ㄇ m, ㄋ n, ŋ), and liquid (ㄌ l). Stops and affricates, can be divided into two parts: unaspirated (p, t, k, tɕ, ts, tʂ), and aspirated (p^h, t^h, k^h, tɕ^h, ts^h, tʂ^h). Phonemes categorized by placement include bilabial (p, p^h, m), labial-dental (f), alveolar (t, t^h, n, l, ts, ts^h, s, tɕ, tɕ^h, ɕ), retroflex (tʂ, tʂ^h, ʂ, ʐ), alveolo-palatal (tɕ, tɕ^h, ɕ), and velar (k, k^h, h, ŋ). Phonemes may be categorized by voicing including voiceless consonants (p, p^h, t, t^h, k, k^h , tɕ, tɕ^h, ts, ts^h, tʂ, tʂ^h, f, h, s, ɕ, ʂ), and voiced consonants (ʐ, m, n, l, ŋ).

TABLE 2

MANDARIN CONSONANT CLASSIFICATION CHART

Placement / Manners			Bilabial	Labial-dental	alveolar		retroflex	velar
Stop	Voiceless	Unaspirated	ㄅ p		ㄉ t			ㄍ k
		Aspirated	ㄆ p^h		ㄊ t^h			ㄎ k^h
Affricate	Voiceless	Unaspirated			ㄗ ʦ	ㄐ ʨ	ㄓ tʂ	
		Aspirated			ㄘ ʦ^h	ㄑ ʨ^h	ㄔ tʂ^h	
fricative	Voiceless			ㄈ f	ㄙ s	ㄒ ɕ	ㄕ ʂ	ㄏ h
	Voiced						ㄖ ʐ	
nasal	Voiced		ㄇ m		ㄋ n			ŋ
liquid	Voiced				ㄌ l			

Vowels in Mandarin

Vowel phonemes include three groups: simple vowels and diphthongs. The simple vowels could be classified into three parts according to the tongue position in the mouth: high position ㄧ、ㄨ、ㄩ (i, u, y), middle position ㄛ、ㄜ、ㄝ、ㄦ (Ω, ɣ, ε, ɚ, ə), and low position ㄚ (ɑ). See Figure1.

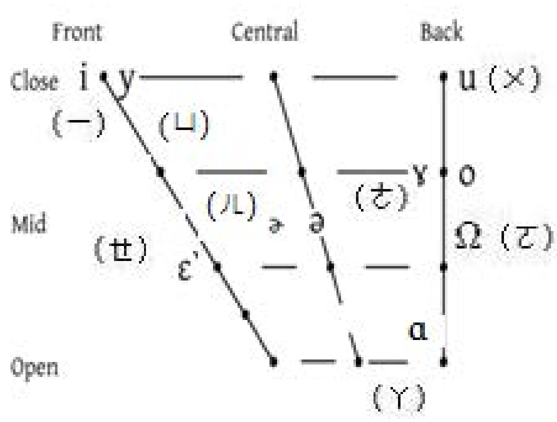

Figure1. Vowels

Vowels can be further categorized by rounded and unrounded lips as well as tense or lax vowel production. The lip rounded vowels include ㄩ /y/, ㄨ /u/, ㄛ/Ω/. The unrounded vowels include 一 /i/, ㄝ /ε/, /ə/, ㄦ /ɚ/, ㄜ/ɣ/, ㄚ/ɑ/. In addition, vowel productions are also described as tense (long) or lax (short). Tense vowels hold for a longer duration and require more tense muscular movement. Lax is shorter and less tense movement. The tense vowels include 一/i/, ㄩ/y/, ㄨ /u/, ㄛ/Ω/, ㄜ/ɣ /, ㄚ/ɑ/. The remaining vowels are lax.

The diphthongs, which are defined as two vowels produced consecutively in the same syllable by moving the articulators smoothly from the position of one to another, include two groups: (1) offglide (ㄞ ɑe, ㄟ ei, ㄠ ɑo, ㄡ ou), (2) onglide (一ㄚ iɑ, 一ㄝ iε, ㄨㄚ uɑ, ㄨㄛ uΩ, ㄩㄝ yε)..

Tones in Mandarin

Tones, defined as any sounds considered with reference to its quality and pitch, an additional feature in Mandarin. Five tones, including high, rising, low-falling, falling, and neutral tone, differentiate the meaning of syllable combinations. For example, 媽/mā/ (high) means "mother," 痲/má/ (high rising) means "linen," 馬/mǎ/ (low-falling) means "horse," 罵/mà/ (falling) means "scold," and 嗎/mȧ/ (neutral tone) means "a phrase-final particle used in questions".

Tones	IPA Marks	Descriptons
1st tone	˥	high level
2nd tone	˧˥	high rising
3rd tone	˨˩˦	low dipping
4th tone	˥˩	high falling
neutral	˙	flat, no emphasis

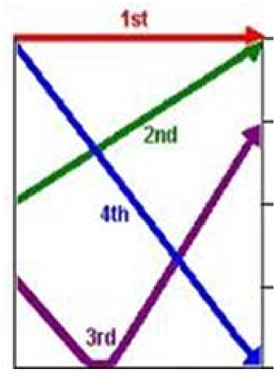

Figure2. Tones

In Mandarin, each syllable represents one word, which usually is accompanied with a tone. The structures of syllables include: (1) consonant (C) + vowel (V), such as 八/pa/; (2) C+V+C, such as 班/pan/; (3) V+C, such as 因/in/; (4) V, such as 衣/i/. Only two final consonants exist in the Mandarin language.

Pilot Study

A pilot study was conducted to determine optimal procedures, words, and materials for the study. The specific purposes of the pilot study was to: (a) test and then select stimuli, (b) identify major phonological deviations of 4-year-old children with speech sound disorders, (c) compare differences of methods in collecting continuous speech samples (CSS) between a wordless book and toys, (d) and calculate mean lengths of responses (MLR). In addition, percentages of consonants correct (PCC) (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997) and percentages of intelligible words (PIW)(Gordon-Brannan & Hodson, 2000) were determined.

The participants in the pilot study consisted of two typically developing (TD) 4-year olds, a female and a male, and two male 4-year olds with speech sound disorders (SSD). The two 4-year-old children with identified speech sound disorders (SSD) were currently receiving speech intervention in a clinic.

Word Selection

The primary investigator (PI) chose 70 words that include all Mandarin consonants and vowels that could be elicited by picture cards. Nouns (e.g., toys, everyday items, colors, sports, animals), and action verbs (e.g., swim, run) were included in the wordlist. Most picture cards could be named spontaneously when the children saw the pictures. The PI adjusted some wordlist choices if the children did not identify certain words. Words were also balanced according to the occurrences of phonemes (see Appendix A). Forty items were chosen for the final stimuli. Words to elicit glides were also added to the final list.

Continuous sample stimuli (CSS)

The PI also collected the CSS via toys and story books. Children readily named the pictures in the story book, but were unable to tell a story using the pictures. CSS were elicited while children played with toys. Some children focused on playing rather than talking about the items. Another limitation was that children repeated the same term when playing with the same toys. In order to overcome this limitation, the investigator prepared a better variety of toys that included more phonemes.

As a result of the pilot study, the PI chose some other toys as the stimuli. Additionally, the PI provides additional assists to help children talk about the toys (appearance, function, material, etc…) rather than simply naming the toys. Finally, the PI planned to use the pilot study procedures in order to collect the most valid CSS.

Mean Lengths of Response (MLR)

The PI counted MLR by dividing the total words in the continuous-speech samples by the number of responses. The MLR in TD children was 5.6 and 7.3, respectively. The MLR in children with SSD was 4.3 and 4, respectively.

In the pilot study, the PI collected 100 words to determine CSS to count MLR; however, this sample was too small to represent appropriate responses in children's speech. Therefore, the PI collected CSS for10 minutes in order to have at least 50 responses. Additionally, the PI found that it was difficult to understand if children used longer sentences rather than phrases or naming.

Percentage of Consonant Correct (PCC)

The PI recorded the CSS and obtained the PCC by dividing the number of correct consonants by the total number of consonants in the sample and then multiplied by 100. PCC for the two TD children were 85% and 84%. PCC for the two children with SSD were 56% and 49%.

Percentage of Intelligible Words (PIW)

Three naïve listeners transcribed the recorded speech samples into words they understood. The PI compared the three transcriptions and word intelligible if two or more of the listeners transcribed words were the same. The PIW was obtained by dividing the intelligible the number of words by the total number of words in CSS. PIW for the TD children was 98% and 99%, respectively. The PIWs for children with SSD was 52% and 57%, respectively. See Table 3.

TABLE 3

CONTINUOUS SPEECH SAMPLES

	SSD1	**SSD2**	**TD1**	**TD2**
MLR	4.3	4	5.6	7.3
PCC	45%	49%	85%	84%
PIW	52%	57%	98%	99%

Phonological Deviations

The PI provided picture cards and procedural information to two licensed speech-language pathologists. They used the words in the list to elicit speech sounds and collected the CSS using toys. When single-word productions were analyzed, few deviations were found. The only phonological deviations by the typically developing children involved the following deviations: affricate, unaspirated, deretroflexiation, and lateralization (see table 8).

The phonological deviations are presented in Table 8.   The common phonological deviations in children with SSD include postvocalic consonant omissions, stopping, backing, dereteoflexiation.

TABLE 4

SUMMARY OF PHONOLOGICAL DEVIATIONS IN PILOT STUDY

Phonological deviations		SSD1	SSD2	TD1	TD2
Omission	Syllable	0	1	0	0
	Prevocalic	0	1	0	0
	Intervocalic	2	1	0	0
	Postvocalic	16	11	0	0
Substitution	Liquid Deviation	2	1	0	0
	Nasal Deviation	16	11	0	0
	Affricate Deviation	4	3	1	0
	Fricative Deviation	3	0	0	0
	Stopping	6	1	0	0
	Backing	5	1	0	0
	Aspirated Deviation	1	0	0	0
	Unaspirated Deviation	1	1	2	0
Other	Diphthong Simplification	0	4	0	0
	Deretorflexiation	6	11	17	6
	Vowelization	2	2	0	0
	Lateralization	1	2	3	1

Summary

The results of the pilot study provided information related to phonological deviations of typically developing children and children with speech sound disorders. Two children with speech sound disorders had moderately unintelligible speech. Phonological deviations produced by them, however, were dissimilar to those produced by typically developing children. Moreover, previous studies indicated that intervention plans should be chosen from the phonological treatment approaches for children with highly unintelligible speech in terms of time efficiency (Hodson, 2010) and critical age. A need exists to further investigate Mandarin phonological deviations of children with highly unintelligible speech.

The pilot study revealed that despite similarities between lingual characteristics in cross-lingual perspectives, some differences might be ignored in the results of the different nature of language. Although many studies of phonological deviations have been conducted in English, Cantonese, and bilingual populations, the results cannot be transferred to deviations in Mandarin.

Furthermore, cultural perspectives need to be considered in terms of the local knowledge even though the same language is spoken in different areas. For example, English is spoken worldwide, especially in the United States, England, and Australia. Some terms, such as *pop*, *wine*, etc. are used in different ways or have different meanings, however. If the assessment tools are used in different areas, the cultural differences need to be considered carefully. For example, *Peabody Picture Vocabulary Test III* (PPVT™; Dunn & Dunn, 1997) was a commonly used language assessment tool in Taiwan. Some vocabulary, (e.g., *igloo*, *pecan*, *saddle*), chosen in the test, is never used in the Taiwanese culture. Such a circumstance might cause invalid diagnostic outcomes. Developing a local assessment instrument is a prerequisite to acquire valid and credible outcomes to meet cultural and regional needs of Mandarin-speaking children all over the world.

A Mandarin assessment tool for highly unintelligible children assesses phonological deviations and then provides optimal directions for intervention plan. Because of limited assessment tools, it is difficult to find adequate participants with SSD. It has been used for children with hearing loss, cerebral palsy, and repaired cleft palates. To focus on these participants might be a start to providing a clearer picture of Mandarin phonological deviations of children with highly unintelligible speech.

Research Questions

The purpose of this study was to investigate intelligibility and major phonological deviations of two groups of Taiwanese-Mandarin-speaking 4-year olds. Two research questions were addressed in this study:

1. Which variables predict the criterion variable, intelligibility (Percentage of Intelligible Words [PIW])?

    (a) Total Occurrences of Major Phonological Deviations (TMOPD)

    (b) Percentages of correct consonants (PCC)

    (c) Mean lengths of response (MLR)

2. What differences are there in speech sound disorders between 4-year-old TD children and children with SSD?

CHAPTER III

METHOD

The purpose of this study was to investigate speech intelligibility and phonological deviations of Mandarin-speaking children in Taiwan. In this chapter, the participants, criteria for inclusion, assessment instruments, and procedures are explained.

Participants

Ten typically developing (TD) children and 10 children with speech sound disorders (SSD) between the ages of 4;0 (years; months) and 4;11 participated in this study. Criteria for inclusion for all participants included: (a) no evidence of organic anomalies related to the speech and hearing mechanisms; (b) passing an audiometric screening procedure; (c) range of receptive vocabulary scores within normal limits for the *Receptive and Expressive Vocabulary Test –Second Edition* (*REVT-II*; Huang, Jian, Zhu, & Lu, 2011); and (d) Mandarin language spoken in their homes.

Typically Developing (TD) Children

TD children were recruited from preschools. Criteria for inclusion included: (a) no prior history of speech sound or language problems; and (b) no concerns regarding intelligibility issues reported by parents or teachers.

Children with Speech Sound Disorders (SSD)

Children with SSD were recruited from the Taipei Veterans General Hospital in Taiwan. They were referred by physicians or speech-language pathologists (SLPs). Criteria for inclusion were failing a speech sound screening test and no prior speech intervention.

Testing for each child took place in one session. Table 5 provides the demographic data.

TABLE 5

DEMOGRAPHIC DATA FOR 20 PRESCHOOLERS

	Boys	Girls
TD	2	8
SSD	7	3

Adult Listeners

Listeners wrote down words they were able to understand from the recordings of continuous-speech samples. Another individual transcribed speech deviations from the word-naming task using the International Phonetic Alphabet (IPA).

Listeners--Group. Three individuals were recruited from the local community. They wrote what they heard in the CSS. Criteria for inclusion were: (a) age range between 18 and 45 years; (b) passing a hearing screening at 25dB; (c) no language or cognitive disability according to self-reports; and (d) no prior contact with any of the children participating in this study.

Transcribers. The Primary Investigator (PI) and one licensed, Mandarin-speaking SLP transcribed the speech deviations for the word-naming task. Pre-training sessions to practice IPA were provided by the PI.

Assessment Instruments

An assessment tool was utilized to collect information regarding the children's phonological deviations. In addition, the process for the development of these assessment materials is explained in the following sections.

Questionnaire

A Mandarin-language questionnaire (Appendix E) was used to collect the children's background information. The questionnaire was adapted from the *Assessment in Speech-Language Pathology: A Resource Manual-Fourth Edition* (Shipley & McAfee, 2009). Questions included medical history, developmental history, and communication information. It took each child's parent or caregiver approximately 5 minutes to complete the questionnaire (See Appendix E).

Audiometric Screening

Pure Tone Audiometry was used to screen participants' hearing. All participants and adult listeners either provided hearing assessment reports or were screened by the PI. Pure tone screening was conducted at 25dB HL for 500, 1000, 2000 Hz.

Receptive Language Assessment

Receptive language scores were obtained using the *Receptive and Expressive Vocabulary Test-Second Edition* (*REVT-II*; Huang, Jian, Zhu, & Lu, 2011), a standardized Mandarin language assessment tool for children between the ages of 3 and 6 years. For the receptive vocabulary test, children pointed to the appropriate picture, according to the test manual procedures. Receptive tests included four parts: naming, category, definition, and reasoning. It took 20 to 30 minutes for the PI to administer the *REVT-II*. Children scoring 1 standard deviation below the mean were to be excluded from this study. All children passed this screening procedure.

According to the manual, internal consistency is between .80~.96, and retest reliability is between .80~.97. Construct validity indicated that significant differences among various ages are significant. Criterion-related validity of this test is significantly related to verbal comprehension scales of the *Wechsler Preschool and Primary Scale of Intelligence™ – Third Edition* (*WPPSI™ – III*; Wechsler, 1997). Standard scores were then used.

Continuous Speech Samples (CSS)

Various toys were utilized to obtain CSS. The CSS was analyzed for the following measures: (a) Percentage of intelligible words (PIW); (b) Percentage of consonants correct (PCC); and (c) Mean lengths of response (MLR). The children played with the toys and the PI also asked questions to elicit the CSS. Speech sample recordings took approximately 10 minutes each. The CSS included at least 50 responses for each child.

The Mandarin Assessment of Phonological Patterns (MAPP)

The MAPP was developed to analyze Major Phonological Deviations. The MAPP is an assessment tool adapted by the PI from the *Hodson Assessment of Phonological Patterns –Third Edition* (*HAPP-3*; Hodson, 2004), which had been developed based on previous research and clinical experiences. Children's errors/deviations were then analyzed.

Forty stimulus items, (age-appropriate toys or pictures,) were used to elicit words. These words were chosen based on a pilot study of two Mandarin-speaking preschool children in Taiwan. As a result of the pilot study, the PI deleted items that could not be named spontaneously by these two children. Three-dimensional objects were used when possible, because younger children show more interest in objects than in pictures (Hodson, 2010). Major Phonological Deviations include: (a) Omissions: vowels/syllables, prevocalic consonants, postvocalic consonants, and consonants in sequences; and (b) Consonant Category Deficiencies, which were analyzed for liquids, nasals, glides, stridents, and velars. An additional deviation option was provided for anterior non-strident obstruents to score backing. It took 15 to 20 minutes to elicit words for the MAPP.

In this protocol, Omissions receive double weighting (both for omissions in word structures and also for omitted consonants in the respective consonant categories. Total Occurrences of Major Phonological Deviations (TOMPD) was calculated and recorded on the MAPP record form (Appendix D).

Recording Equipment

The research protocol was administrated by the PI in a quiet room. Speech samples from children were recorded using a digital audio recorder (SONY PCM-M10) at a 44.1-kHz sampling rate (16-bit quantization). A professional microphone (AUDIO-TECHNICA AT899) was positioned on the top of each child's head approximately 10 cm from the mouth.

Listening Equipment

All listeners were seated in front of the speaker in a quiet classroom. The output level was monitored by the PI.

Procedures

Preliminary

All participants were assessed individually, and their utterances were recorded during the assessment. Total assessment duration took 45-60 minutes. Two sessions were scheduled in advance. All tests were administered in a quiet room with background noise below 50dB SPL (based on a portable sound pressure meter).

The PI explained the purposes and procedures of this study to each caregiver. An informed consent form (Appendix B) was obtained from the caregiver. In addition to the informed consent form, a parent answered a questionnaire (Appendix E). Next, the receptive language test was administered. Finally, the PI showed the toys and then played with the children. The children's connected-speech samples were also recorded.

Speech Assessment

The PI administered the Mandarin Assessment of Phonological Patterns (MAPP). Ten items were shown simultaneously on a table. The child named the objects or pictures while he or she played with these toys or items. If the child was not able to name the item, the PI modeled the word and used delayed imitation. The speech samples were recorded via a digital audio recorder and a microphone.

Phonetic transcription

The PI phonetically transcribed phonological deviations live at the time of utterance. Additionally, one experienced SLP listened to the recorded speech samples and independently transcribed deviations phonetically. The two independent transcriptions were compared for inter-rater reliability. Ten percent of the randomly selected samples were again transcribed to determine intra-judge reliability. A point-by-point agreement index was obtained for inter-judge and intra-judge reliability. Whenever discrepancies between the transcriptions occurred, the PI and SLP replayed the recordings until a consensus was reached. The Total Occurrences of Major Phonological Deviations (TOMPD) were calculated based on the consensus transcriptions.

Continuous Speech Samples

Intelligible Words. The primary investigator deleted the first 20 words from the CSS and then utilized the next 50 words to obtain the PIW. The PI paused between each sentence. In addition, one randomly selected sentence was repeated at the end for intra-judge comparisons. The PI wrote down the words. Three adult listeners then listened to the recorded speech samples and wrote down the words they were able to understand. If they could not understand a word, they were told to put a dash. If an unusual situation occurred, the recording was repeated one time. Tone homonyms were accepted. Then, the words were compared to determine intelligible words. Percentages of intelligible words (PIW) were obtained by dividing the words that matched by 50 words (Flipsen, 2006; Hodson, 2010).

PCC. The PI listened to 50 words from the CSS and wrote down these words. The consonants in those words were identified. The PCC was obtained by dividing the number of correct consonants by the total number of consonants in the sample (Shriberg & Kwiatkowski, 1982).

MLR. The PI wrote down 50 responses from the CSS. The MLR was obtained by dividing the total number of words in the CSS by 50.

Data Analysis

All statistical analyses were performed using SPSS 22.0. The Criterion variable for the multiple regression analysis was the PIW. Potential predictor variables included TOMPD, PCC, and MLR. The stepwise model was used. Additionally, T-tests were was conducted to compare the differences of major phonological deviations between TD children and children with SSD.

CHAPTER IV

RESULTS

The primary purpose of this study was to investigate speech sound performances of 4-year-old Mandarin-speaking preschoolers. Speech sound accuracy scores were based on phonetic transcriptions of each child's productions from the 40-item naming task, Mandarin Assessment of Phonological Patterns.

Reliability

The Primary Investigator (PI) phonetically transcribed phonological deviations live at the time of utterance. Additionally, one experienced SLP listened to the recorded speech samples and independently transcribed deviations phonetically. The two independent transcriptions were compared for inter-rater reliability. Ten percent of the randomly selected samples were again transcribed by the PI to determine intra-judge reliability. A point-by-point agreement index was obtained for inter-judge and intra-judge reliability. Inter-judge reliability for phonetic transcriptions was .89. The intra-judge reliability for phonetic transcriptions was .9.

Predictor Variables and Intelligibility

The primary research question was to determine which variables (mean of length of response, phonological deviations, percentage of consonants correct) predict percentages of intelligible words in Mandarin specified by unfamiliar listeners. A regression analysis was conducted. Only one variable predicted intelligibility as a result of this regression model. Phonological deviations accounted for 74% of the variance ($F=-49.875$, $p=.000$). Table 6 provides the regression analysis results.

TABLE 6

REGRESSION ANALYSIS RESULTS FOR 20 PRESCHOOLERS

Variables	R square	Beta	*T*	*p*
TOMPD	.735	-.857	-7.062	.000**
MLR		.181	.153	.153
PCC		.290	.165	.165

**p<.001

Table 7 provides Correlations and levels of significance. The TOMPD and the PIW were highly correlated ($r = -.857$, $p < .001$). Correlations for the MLR were lower ($r = .384$, $p > .001$). The PCC and PIW were also highly correlated ($r = -.793$, $p < .001$).

TABLE 7

CORRELATION MATRIX FOR VARIABLES

	PIW	TOMPD	MLR	PCC
PIW	--	-.857**	.384	.793**
TOMPD		--	-.250	-.808**
MLR			--	.361
PCC				--

**p<.001

Percentage of Intelligible Words (PIW)

Continuous-speech samples (CSS) were obtained individually while children manipulated and talked about toys. Digital audio recordings were obtained to analyze the CSS. Three unfamiliar listeners wrote down words that they understood from the samples. These were compared to the true words from the CSS. PIWs were obtained via percentage means of three listeners. The PIW mean for TD children was 91.3% (80-100%), and the PIW mean for children with SSD was 40.2% (11-68%).

Phonological Deviations

The second research question was to determine if differences in phonological deviations occurred between two groups of children (TD and SSD). The PI transcribed the target words using the International Phonetic Alphabet (IPA) as each child named the objects of the MAPP for each group of children and listened to the recording again. Then the PI categorized omissions and consonant category deficiencies.

Total Occurrences of Major Phonological Deviations (TOMPD) were calculated for each child. Phonemic omissions were counted for Consonant Category Deficiencies when the consonant phoneme was omitted, as well as Segment Omissions. TOMPD scores for children in this study are provided in Table 8. The overall TOMPD means were 3.4 for TD children and 45.4 for children with SSD.

Differences in TOMPD were examined. A t-test indicated that differences between the two groups were significant ($t=-6.939$, $p< .001$).

TABLE 8

TOMPDS FOR 20 PRESCHOOLERS

	N	Mean	SD	Range
TD Children	10	3.40	2.989	0-9
SSD Children	10	45.40	18.904	22-83

Results from the MAPP were analyzed for Major Phonological Deviations. T-tests were used to examine differences between the means of the two groups (See Table 10). Differences between the two groups were significant for consonant sequence omissions, liquid deficiencies, nasal deficiencies, and strident deficiencies.

TABLE 9

MEANS FOR MAJOR PHONOLOGICAL DEVIATIONS

	TD	SSD
Vowel Omissions (i.e., syllables)	0	1.9
Prevocalic Consonant Omissions	0	2.7
Postvocalic Consonant Omissions	.7	4.1
Consonants Sequence Omissions	0	5.1
Liquid Deficiencies	.3	2.5
Nasal Deficiencies	.7	7.3
Glide Deficiencies	.1	2.4
Strident Deficiencies	1.6	14.0
Velar Deficiencies	0	2.3

TABLE 10

MAJOR PHONOLOGICAL DEVIATIONS T-TEST RESULTS

	t	p
Postvocalic Consonant Omissions	-2.818	.011*
Consonants Sequence Omissions	-4.553	.000*
Nasal Deficiencies	-3.727	.002*
Strident Deficiencies	-4.312	.000*

*p<.0125

Mean Lengths of Response (MLR)

The PI wrote down 50 responses from the CSS for each child. The MLRs were obtained by dividing the total number of words in the CSS by 50 responses. The MLR mean for TD children was 6.06; the MLR for children with SSD was 5.20.

Percentages of Consonant Correct (PCC)

The PI listened to 50 words from the CSS and wrote down words. The consonants in those words were identified. The PCC was obtained by dividing the number of correct consonants by the total number of consonants in the sample (Shriberg & Kwiatkowski, 1982). The PCC mean for TD children was 89%, and the PCC mean for children with SSD was 60%.

CHAPTER V

DISCUSSSION

The primary purpose of this study was to investigate Mandarin-speaking-children's speech abilities. This study was designed to determine which factors could predict the percentages of intelligible words. The second purpose was to compare the differences of speech sound productions between typically developing (TD) children and children with speech sound disorders (SSD). The results are discussed in this chapter. In addition, the clinical implications, the limitations of this study, and future research needs are addressed.

The results of the criterion variable, percentages of intelligible words (PIW), were compared with scores of three predictor variables: phonological deviations, percentages of consonants correct (PCC), and mean lengths of response (MLR) to determine if any contributed significantly to the variance of the PIW. Major phonological deviations for TD children and children with SSD were compared.

Predictor Variables

The results of this study indicate that the Total Occurrences of Major Phonological Deviations (TOMPD) was the strongest predictor of percentages of intelligible words for 4-year-old children. These findings are similar to studies in other languages (e.g., Magnus, Hodson, & Schommer-Aikins, 2011; Prezas, Hodson, & Schommer-Aikins, 2012). The TOMPD gives extra weighting for omissions. When children omit sounds (e.g., *koŋloŋ-> o o*), listeners have more difficulty comprehending their speech.

Another variable was Percentages of Consonant Correct (PCC; Shriberg & Kwiatkowski, 1982). The PCC was highly correlated with the PIW; however, the PCC may not be as sensitive to speech sound errors because all types of error sounds are weighted equally (e.g., all sound errors are weighted the same as the much more severe omissions). Some research results also agree that the PCC may not be a sensitive indicator of severity (e.g., Austin & Shriberg, 1997; Preston & Edwards, 2010). Distortions may not reduce speech intelligibility as much as other deviations. In most assessment procedures, distortions, substitutions, and omissions receive the same scoring/weighting.

The results of this study indicated that two variables, TOMPD and PCC, were highly correlated with PIW. The TOMPD was the only measure that contributed significantly to the PIW variance.

Another variable, MLR, was scored in the present study. The overall MLR was 5.63, which is higher than some studies in English (Gard, Gilman, & Gorman, 1993; Magnus, Hodson, & Schommer-Aikins, 2011). Reasons for differences may include the structure of sentences in Mandarin. Words usually were composed by 2 or 3 words. For example, a *dinosaur* is called "恐龍" [*koŋ loŋ*], which is composed by two single words. The word, "恐" [*koŋ*] exists independently, and its meaning is *frighten* or *threaten*. The word, "龍" [*loŋ*] exists independently, and its meaning is *dragon*. Therefore, MLR in Mandarin may be higher than in English in continuous-speech samples. Published research, regarding MLR in Mandarin, however, is not available.

Intelligibility

Intelligibility has been described as "the most useful instrument of oral communication competence" (Metz, Samar, Schiavetti, Sitler, & Whitehead, 1985). In the present study, intelligibility was obtained by three listeners writing down words they could understand, counting the number of intelligible words, and converting to percentages (Hodson, 2010).

Major Phonological Deviations

Another research question was to investigate the differences in speech sound productions between TD children and children with SSD. The results indicated that differences between the means for the two groups were significant ($t=-6.939, p < .001$).

The PI analyzed factors that were counted for TOMPD. The Occurrences of Major Phonological Deviations for 20 participants are provided in the Appendices. For TD children, there were no omissions of vowels, prevocalic consonants, or consonants in sequences. A small number of postvocalic consonant omissions occurred, which is similar to previous studies in English and Mandarin (Dunn & Davis, 1983; Grunwell, 1987; Haelsig & Madison, 1986; Jeng, 2011; McLeod et al., 2013). According to Jeng's study in Mandarin, consonant omissions, backing, and fronting occurred less than 10% by the age of 4 years, which is comparable to findings in the present study.

For children with SSD, postvocalic consonant omissions and consonant sequence omissions occurred; additionally, vowel omissions and prevocalic consonants omissions were common in one speech sample of child with highly unintelligible speech. Prezas, Hodson and Schommer-Aikins found that the highest percentages of phonological deviations for both English- and Spanish-speaking bilingual children were liquids deviations, omissions of consonants in sequences, and glide deficiencies.

In addition, strident deficiencies were the most common phonological deviations for all participants in the current study. According to developmental milestones for speech sound acquisition (e.g, Dyson & Paden, 1983; Haelsig & Madison, 1986; Stoel-Gammon; 1985), children produce adult-like speech and have few error sound productions by the age of four.

The children with SSD, however, produced some atypical phonological deviations, (e.g., backing). These results are comparable to a previous Mandarin study (Chi, 2011). Another prevalent phonological deviation for children with SSD was nasal deficiencies. This finding was different from other Mandarin studies (Chi, 2001; Jeng, 2011). The reasons why nasal deficiencies were not reported for children with SSD may be related to different assessment procedures. 注音符號(Bopomofo) symbols rather than International Phonetic Alphabet (IPA) were utilized in previous Mandarin studies. Postvocalic consonants, /n/ and / ŋ /, were embedded in vowel categories in the Bopomofo system.

Speech Sounds in the Mandarin Language

Consonant cluster reductions have not been mentioned in prior Mandarin studies. Consonant clusters (e.g., 短邊 *twǎn*, *pjān*) do exist in Mandarin. In Taiwan, "Bopomofo" is the most general sound system used; however, some symbols in the Bopomofo system include combinations of vowels and consonants. For example, the symbol "ㄢ" is pronounced "an," which is composed of "a" and "n." Another phenomenon in the Bopomofo system is the combination of consonants and vowels. For example, the combination of "ɕ," "i," and "a" is pronounced 蝦"ɕja" rather than "ɕia." In this case, a consonant sequence, "ɕj" occurs. These phonological deviations were not reported before. Postvocalic consonant omissions have not been mentioned in previous studies (e.g., Jeng, 2011; Young, Lai, Liao, 1984).

Additionally, some phonological deviations, such as deaspiration, frication, that were suggested as common phonological deviations in previous studies (e.g., Jeng, 2011; Young, Lai, & Liao, 1984) did not occur in the present study. For example, when a child substituted “高麗菜 *i*”(*kau li sa)* for “*kau li ts*ʰ*ai*,” the words still could be understood. Further studies are needed to determine exactly which deviations are critical for Mandarin assessment. Another similar situation pertained to deretroflex substitutions. For example, while the word “獅子”*(tʂ ts ɨ)* was produced as into “*ts tsɨ*,” individuals still could comprehend this word. The deretroflex substitution is very common error in Mandarin adult speech as well because of the dialect, Taiwanese. That is, most Taiwan-Mandarin-speaking adults speak Mandarin and Taiwanese simultaneously, some substitutions occurred in the Mandarin and Taiwanese languages. This substitution usually has no significant impact on comprehending words in continuous speech.

In conclusion, the TOMPD was the strongest predictor of percentages of intelligible words for 4-year-old Mandarin-speaking children in this study. Additionally, the major phonological deviations, including postvocalic omissions, consonant cluster reductions, and nasal deficiency, occurred for children with SSD. The major phonological deviations were not mentioned in the previous studies.

Clinical Implications

This investigation provided important information pertaining to phonological deviations and speech intelligibility of 4-year-old Mandarin-speaking children. Phonological deviations emerged as the most significant predictor of PIW in Mandarin. A phonological assessment is often utilized to evaluate children who have highly unintelligible speech in English and Spanish (Hodson, 2010; Prezas, Hodson, & Schommer-Aikins, 2012). In Taiwan, speech acquisition norms (Xi, Xu, & Xu, 2004) are the most common assessment tool in hospital or clinical settings at present. Based on the results of this study, the SLP could consider using a Mandarin phonological assessment instrument to evaluate children who have highly unintelligible speech.

Results from this study yielded another important finding. Phonological deviations for children with SSD include omissions, which has not been a part of speech sound assessment previously. Based on the data in the current study, children with SSD, especially children with highly unintelligible speech, should be evaluated via a phonological assessment tool. Phonological data are critical in order to identify and develop optimal intervention goals. Also, The TOMPD could be used as an accountability measure for intervention.

Limitations of the Study

This study had only 20 participants. Additionally, only one age group (4-year olds) was included in this study. The relationships between intelligibility and the factor involving children from multiple ages should be investigated.

Another limitation of this study is that not all children with speech sound disorders produced highly unintelligible speech (PIW < 10%). Clinically, few highly unintelligible 4-year-old children are referred unless they have organic impairments. Whether the characteristics of Mandarin are easier to acquire for children or not also needs to be considered.

Future Research

Along with the limitations mentioned above, additional research in needed for evaluating intelligibility of Mandarin-speaking children. Multiple factors, for example, potentially determine overall intelligibility (e.g., breathiness, voice quality). In addition, relationships between TOMPD and other measures of intelligibility (e.g., rating of intelligibility; Gordon-Brannan & Hodson, 2000) should be explored.

Based on the findings of the current study, occurrences of phonological deviations were the largest predictor for the PIW. Major phonological deviations need to be investigated further.

Additionally, more children with highly unintelligible speech need to be recruited. More age groups, for example, are needed to compare differences among different age groups (i. e., 3-, 5-, 6-year-olds).

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APPENDICES

APPENDIX A

CONSENT FORM

Purpose: You are invited to participate in a study of investigating Taiwanese-Mandarin-speaking preschoolers' phonological system and intelligibility. We hope to learn preschoolers' information among intelligibility, total occurrence of main phonological deviations, percentages of consonant correct, mean lengths of response, and age. In addition, we will compare the performances of the two groups of 4-years olds: (a) typically developing (TD) children, and (b) children with speech sound disorders (SSD).
.
Participant Selection: You were selected as a possible participant in this study because you are one of 40 preschoolers between the ages of 4;0 (years;months) and 4;11 represented the following two groups: (a) children with SSD who are referred by physicians or speech language pathologists; (b) TD children.

Explanation of Procedures: All participants will be assessed individually. Total assessment duration will take 45-60 minutes.
The co-investigator will explain the purposes and procedures of this study to the caregiver(s). An informed consent form will be obtained from the caregiver. Along with the informed consent form, a parent will answer the questionnaire. Next, the receptive language test will be administered. Finally, the co-investigator will show the toys and then play with the children.

Discomfort/Risks: There is no risk or discomfort in any of these procedures. Pointing out pictures, naming objects and pictures as well as playing with toys will not cause any risks or discomfort for the participants. Children enjoy these activities. If the child appears to feel physical or psychological discomfort during the assessment, the administration will be stopped immediately. A break will be taken, and if appropriate, the assessment session will be rescheduled.

Benefits: The benefits to human or scientific knowledge include: (a) to investigate Taiwanese-Mandarin information about intelligibility and phonological deviations/patterns of TD children and children with SSD; (b) to provide an assessment tool for clinical purposes.

Confidentiality: Audio recording data and documentation will be stored carefully. The participants' information will be coded. The identifiers will be separated from the data. All participants' background information, record forms and transcription sheets will be stored in a locked box and kept by the co-investigator for 3 years after the completion of the study. Then, all documents will be shredded. The recorded audio files will be saved as protected files. Three years after completing the study, all recorded audio files will be erased. In addition, the documents and final reports of children with speech sound disorders will be kept in the children's file in hospitals.

Refusal/Withdrawal: Participation in this study is entirely voluntary. Your decision whether or not to participate will not affect your future relations with Wichita State University and/or (Include name of any other institution or agency involved). If you agree to participate in this study, you are free to withdraw from the study at any time without penalty.

Contact: If you have any questions about this research, you can contact: Dr. Kathy Strattman, kathy.strattman@wichita.edu or Kai-Mei Chen, kxchen3@wichita.edu. If you have questions pertaining to your rights as a research subject, or about research-related injury, you can contact the Office of Research Administration at Wichita State University, Wichita, KS 67260-0007, telephone (316) 978-3285.

You are under no obligation to participate in this study. Your signature indicates that you have read the information provided above and have voluntarily decided to participate.

You will be given a copy of this consent form to keep.

_______________________________________ ________________
Signature of Subject Date

_______________________________________ ________________
Signature of Parent or Legal Guardian Date

_______________________________________ ________________
Witness Signature Date

APPENDIX B

PARENT CONSENT FORM IN MANDARIN LANGUAGE

主持人簽名/日期

臺北榮民總醫院臨床試驗/研究計畫
受試者同意書

計畫書編號： 計畫名稱：四歲台灣華語兒童音韻系統與語音清晰度評量
執行單位：復健醫學部 主要主持人：復健醫學部/主治醫師/楊翠芬/電話: (02)28757360 本計畫二十四小時緊急聯絡人及電話：楊翠芬(0938)591963
受試者姓名： 性別：　　　　出生日期： 病歷號碼： 通訊地址： 聯絡電話： 受試者緊急聯絡人：　　　　　　電話： 通訊地址：
法定代理人/監護人/輔助人或有同意權人姓名： 與受試者關係： 性別：　　　　出生日期： 身分證字號： 通訊地址： 聯絡電話：

1.藥品、醫療技術、醫療器材全球上市現況簡介／研究背景簡介： 本研究計畫不涉及藥品、醫療技術、醫療器材。 研究背景:語音對於四歲兒童的發展扮演相當重要的角色。探討語音清晰度是臨床與研究的第一步。然而，華語相關的研究不多。過去，雖有許多英文的一般發展和語音障礙兒童音韻類型研究，然而華語的相關研究有限。音韻類型在不同語言雖有其共通性，但是，因為語言本質的不同，它也存在著歧異性。此外，探討華語學前兒童的語音清晰度之相關研究也不多。探討華語一般發展及語音障礙兒童中，可預測語音清晰度的音韻類型有其必要性。 此外，目前主要診斷語音障礙兒童是以全對或全錯的方式計算錯誤語音。這很可能忽略了對不同類型錯誤語音的判斷。因此，需要探討語音清晰度的相關因素，包含以華語為主的台灣兒童，以決定最佳的語音介入目標。 本研究採立意取樣（purposive sampling)，由幼稚園老師、家長轉介一般發展兒童，復健醫科醫師及語言治療師協助轉介符合選樣條件的語音障礙個案，徵得個案家長同意後進行施測，預計招收 20 位一般發展兒童及 20 位語音障礙兒童。本院預定招收 20 位語音障礙兒童。
2.試驗／研究目的 本研究的主要目的在探討台灣華語四歲兒童的音韻類型與語音清晰度。 其中，包含三個次要目的:（一)探討哪個變項能預測語音清晰度:（1)主要音韻類型的總發生次數(TOMPD);（2)子音正確率(PCC);（3)回應語句的平均長度(MLR);（4)年齡。(二)比較一般發展兒童及語音障礙兒童主要的音韻類型。(三)探討兩組兒童最常發生的音韻錯誤類型。

3.試驗／研究之主要納入與排除條件 (1)所有研究對象之納入標準：(a)無器質性異常。（b）語言理解測驗分數在正常範圍。（c）在家以華語為主要溝通語言。 (2)兒童選擇標準： (a)一般發展兒童：(i)沒有任何語言或言語病史。(ii)家長或教師沒有任何語音清晰度的問題。(iii)幼稚園招募。 (b)語音障礙兒童：(i)兒童接受篩檢，未通過篩檢之中度以上語音障礙 兒童將納入本研究。(ii)兒童若已接受兩個月以上治療將排除在本研究 之外。(iii)由醫師或語言治療師轉介。
4.試驗／研究方法及相關配合檢驗 (1) 前置作業: 您的孩子將進行個別施測。施測過程全程錄音。測驗時間大約 45-60 分鐘。施測過程將在背景噪音低於 60 分貝 (沒有其他人說話、機器運作干擾)的安靜房間進行。 (2) 研究員向您解釋研究目的及流程。您需填寫同意書及基本資料表。 (3) 研究員施測兒童語言理解與表達測驗(理解語言部分)。 (4) 研究員施測華語音韻測驗(MAPP)。每次放置 10 個玩具或圖片在桌上，由您的孩子命名。若您的孩子無法自行命名，則由研究員示範後進行延後模仿。語音樣本將使用麥克風及錄音機錄音。 (5) 研究員與您的孩子玩各種玩具、問問題，以蒐集最佳的語音樣本。連續語音樣本將用來分析: (1)語音清晰度(PIW); (2)子音正確率(PCC); (3)語句平均長度(MLR)。語音樣本將使用麥克風及錄音機錄音。每個連續語音樣本大約花 5-10 分鐘，並包含至少 50 個回應語句。

5.可能發生的副作用、發生率及處理方法： 本研究的施測過程沒有任何風險或造成身心不適的情況。指稱圖片、物品及圖片命名、以及玩玩具對話並不會對受試者造成任何風險或身心不適的狀況。兒童很喜愛這些活動。若您的孩子在施測過程中出現任何身心不適的狀況，測驗將立即停止。將視您孩子的情況稍作休息或是另外規劃其他時間進行施測。您與孩子的評量資料及個人相關資料僅供本研究使用，絕對保密不會對外公開。同樣地，在整個研究過程中，您也可隨時提出退出本研究，我們將會尊重您意願。 心理方面—您的孩子在回應或指稱圖片時不確定答案或是不知道如何回答，可能會有挫折感。研究員將說明施測結果不會影響在學校或其他地方的表現。 社會方面—目前無法預知對您及您的孩子的社會權益有何種影響，但計畫主持人會小心維護您的孩子資料的機密。但若他人(例如您及您的孩子的保險公司)無意中得知您參與試驗的結果，或許會產生對您不利的影響。但此風險極低，因為您和孩子的資料會被以極機密保存。任何的研究報告中將不會有您和孩子的個人資料，此研究的結果亦不會與臨床研究資料庫連結。因此，透過這些適當的處理，我們可以盡可能的降低這些風險對您的影響。
6.其他可能之治療方式及說明 您及孩子可決定是否參加本研究，若不參加研究時，您的孩子仍可繼續接受語言治療。您和孩子的意願將不會影響您與醫院或楊醫師的關係。
7.試驗／研究預期效果 您若參與本研究，研究員將提供您及兒童接受性語言評估及語音清晰度、音韻類型分析之結果。 本研究將(a) 提供台灣華語學前一般發展與語音障礙兒童之音韻錯誤/類型之訊息; (b) 提供臨床測驗工具。
8.試驗／研究進行中受試者之禁忌、限制與應配合之事項： 無

9.機密性 對於您的孩子檢查的結果及醫師診斷，計畫主持人將持保密的態度，一個研究號碼將會取代您的孩子的姓名。除了有關機構依法調查外，計畫主持人會小心維護您的孩子的隱私。 您簽署受試者同意書後，您的孩子的原始醫療紀錄可直接受監測者、稽核者、人體試驗委員會及主管機關檢閱，以確保臨床試驗過程與數據符合相關法律及法規要求，並承諾絕不違反受試者身分之機密性。 所有的錄音檔及文件將小心保存。研究代碼與您的孩子的姓名資料將分別保存。錄音資料將保存於保密資料夾。所有參與者的背景資料、錄音檔和轉錄資料將保存於臺北榮總復健醫學部，由計畫主持人楊翠芬醫師保管。研究結束後，所有資料將依法銷毀。
10. 損害補償與保險： ● 如依本研究所訂臨床試驗計畫，因而發生不良反應或傷害，由臺北榮民總醫院負補償責任。 ● 如依本研究所訂臨床試驗計畫，因而發生不良反應或損害，臺北榮民總醫院願意提供專業醫療照顧及醫療諮詢。您不必負擔治療不良反應或損害之必要醫療費用。 ● 除前二項補償及醫療照顧外，本研究不提供其他形式之賠償或補償。若您不願意接受這樣的風險，請勿參加試驗。 ● 您不會因為簽署本同意書，而喪失在法律上的任何權利。 （本研究未投保責任保險。）
11. 研究的資料將如何處理及儲存地點： 您的孩子的所有資料僅供研究計畫使用。所有的錄音檔及文件將小心保存。研究代碼與您的孩子的姓名資料將分別保存。錄音資料將保存於保密資料夾。所有參與者的背景資料、錄音檔和轉錄資料將保存於臺北榮總復健醫學部，由計畫主持人楊翠芬醫師保管。研究結束後，所有任何資料將依法銷毀。
12. 誰可以使用您的資料： 依「人體研究法」規定，唯有計畫主持人復健醫學部楊翠芬醫師，及本計畫之研究員陳凱玫可於研究進行期間依本研究所訂臨床試驗計畫使用您的資料，如於研究結束後仍需使用，將依法請您另簽一份同意書。

13. 研究結束後資料處理方法： ☑ 依法由臺北榮民總醫院銷毀。 ☐ 同意繼續於研究結束後，由臺北榮民總醫院依法保存（如儲存於剩餘檢體組織庫）從事後續研究。於進行其他研究前，將依法請您簽署另外一份同意書。
14. 試驗之退出與中止及資料處理方法 您可自由決定是否參加本試驗；試驗過程中也可隨時撤銷同意，退出試驗，不需任何理由，且不會引起任何不愉快或影響其日後醫師對您的醫療照顧。試驗主持人或贊助廠商亦可能於必要時中止該試驗之進行。 ☑依法由臺北榮民總醫院銷毀 ☐同意繼續於研究結束後，由臺北榮民總醫院依法保存（如儲存於剩餘檢體組織庫）從事後續研究。於進行其他研究前，將依法請您簽署另外一份同意書。
15.如本計畫研究成果獲得學術文獻發表、智慧財產及實質效益時，臺北榮民總醫院將依法作為從事疾病診斷、預防、治療及研究等醫學用途。

16.受試者權利

1. 參加本試驗您不須繳交任何費用。
2. 本試驗不在全民健康保險之給付範圍。
3. 試驗過程中，與您的孩子的健康或是疾病有關，可能影響您的孩子繼續接受臨床試驗意願的任何重大發現，都將即時提供給您。
4. 如果您在試驗過程中對試驗工作性質產生疑問，對身為患者之權利有意見或懷疑因參與研究而受害時，可與本院之人體試驗委員會聯絡請求諮詢，其電話號碼為：(02)2875-7384。
5. 為進行試驗工作，您的孩子必須接受主持人__楊翠芬醫師__的照顧。如果您現在或於試驗期間有任何問題或狀況，請不必客氣，可與在_臺北榮民總_醫院_復健醫學_部的___楊翠芬醫師___聯絡（24小時聯繫電話：_ 0938591963_）。
6. 在您的同意下，研究員將以書面通知您的主治醫師。
7. 本同意書一式2份，主持人已將同意書副本交給您，並已完整說明本研究之性質與目的。研究員__陳凱玫__已回答您有關研究的問題。

17.簽名

（一）主要主持人、或協同主持人已詳細解釋有關本研究計畫中上述研究方法的性質與目的，及可能產生的危險與利益。

主要主持人／協同主持人：__________（簽名）

日期：______年______月______日（請務必填寫）

試驗說明者：__________（簽名）

試驗說明者與試驗之關係：

日期：______年______月______日（請務必填寫）

（二）受試者已詳細瞭解上述研究方法及其所可能產生的危險與利益，有關本試驗計畫的疑問，業經計畫主持人詳細予以解釋。本人同意接受為臨床試驗計畫的自願受試者。

受試者：__________（簽名）

日期：＿＿＿年＿＿＿月＿＿＿日（請務必填寫）

註 1. 本受試者同意書適用範圍為年滿二十歲以上之成年人，且受試者必須由其本人簽名，並且載明日期始得生效。

法定代理人＿＿＿＿＿＿（簽名）

日期：＿＿＿年＿＿＿月＿＿＿日（請務必填寫）

註 2. 未滿二十歲之受試者或受法律之監護宣告者，須由法定代理人簽名始生效。

註 3. 受試者為無行為能力(未滿七歲之未成年人者或受監護宣告之人)，由法定代理人為之；受監護宣告之人，由監護人擔任其法定代理人。

註 4. 受試者為限制行為能力者(七歲以上之未成年人)，應得其本人及法定代理人之同意。

註 5. 年滿七歲以上未滿十二歲的受試者：須另加一份贊同同意書，請用圖案表示或注音，取得其贊同。

監護人/輔助人或有同意權人＿＿＿＿＿＿（簽名）

與受試者之關係（請圈選）：本人、配偶、父、母、兒、女、

其他：＿＿＿＿＿＿＿＿＿＿

日期：＿＿＿年＿＿＿月＿＿＿日（請務必填寫）

註 6. 受試者因精神障礙或其他心智缺陷，致其為意思表示或受意思表示，或辨識其意思表示效果之能力，顯有不足，而受法院之輔助宣告者，應得輔助人之同意。

註 7. 受試者雖非無行為能力或限制行為能力者，但因意識混亂或有精神與智能障礙，而無法進行有效溝通和判斷時，由有同意權之人為之。前項有同意權人為配偶及同居之親屬。其順序如下，一、配偶。二、成年子女。三、父母。四、兄弟姊妹。五、祖父母。

（三）受試者、法定代理人、監護人/輔助人或有同意權之人皆無法閱讀時，應由見證人在場參與所有有關受試者同意之討論。並確定受試者、法定代理人、監護人/輔助人或有同意權之人之同意完全出於其自由意願後，應於受試者同意書簽名並載明日期。

茲證明主要主持人、或協同主持人已完整地向受試者或其法定代理人、監護人/輔助人或有同意權之人解釋本試驗的內容。

見證人 1＿＿＿＿＿＿（簽名）

身分證字號：

日期：______年______月______日(請務必填寫)

聯絡電話：

通訊地址：

見證人2____________(簽名)

身分證字號：

日期：______年______月______日(請務必填寫)

聯絡電話：

通訊地址：

註8. 研究/試驗相關人員不得為見證人。

註9. 若意識清楚，但無法親自簽具者且無親屬或關係人在場，得以按指印代替簽名，惟應有二名見證人。

APPENDIX C

Raw Data

	Gender	Age in months	REVT Z-score	PIW-AVE	TOMPD	MLU	PCC
T001	Girl	4;0	87	83.33	5	5.74	85%
T004	Girl	4;1	107	80.00	4	4.1	97%
T005	Girl	4;1	121	87.33	0	4.62	84%
T007	Girl	4;3	115	90.00	9	4.62	83%
T008	Girl	4;5	104	98.67	7	9.68	90%
T009	Girl	4;5	125	86.00	4	5.62	90%
T011	Boy	4;6	133	90.67	0	4.74	96%
T013	Boy	4;8	120	99.33	1	5.62	85%
T014	Girl	4;10	97	100.00	2	9.5	92%
T016	Girl	4;11	108	98.00	2	6.38	95%
S001	Girl	4;3	100	68.00	27	4.86	65%
S002	Boy	4;3	104	58.00	32	4.88	52%
S003	Boy	4;5	106	59.33	38	6.16	75%
S004	Girl	4;4	100	10.67	83	4.66	33%
S007	Girl	4;6	109	32.67	38	6.26	71%
S008	Boy	4;0	91	28.67	49	6.18	77%
S009	Boy	4;2	116	28.00	22	4.48	51%
S010	Boy	4;0	100	24.00	40	4.64	64%
S011	Boy	4;2	109	52.00	62	5.16	48%
S012	Boy	4;5	97	41.33	63	4.76	72%

APPENDIX D

MANDARIN ASSESSMENT OF PHONOLOGICAL PATTERNS

Transcriptions of Stimulus Words

1. ice cream/冰淇淋 ___ piŋ tɕ^{h}i lin	11.sliding/溜滑梯___ lijo hwɑ t^{h}i	21.snowman/雪人___ ɕyɛ ʐʌn	31.umbrella/雨傘___ y sɑn
2. grape/葡萄___ p^{h}u t^{h}ɑʊ	12.cabbage/高麗菜 ___ kɑʊ li ʦ^{h}ɑi	22.finger/手指___ ʂoʊ tʂɨ	32.ear/耳朵___ ɝ tuwΩ
3.mask/面具___ mɪjɛn tɕy	13.truck/卡車___ k^{h}ɑ tʂ^{h}ɤ	23. squirrel/松鼠___ soŋ ʂu	33.cloud/白雲___ pɑi yn
4.panda/貓熊___ mɑʊ ɕoŋ	14.traffic light/紅綠燈 __ hoŋ ly tʌŋ	24.hot dog/熱狗___ ʐɤ koʊ	34. coke/可樂___ k^{h}ɤ lɤ
5. frisbee/飛盤___ fei p^{h}ɑn	15. curtain/窗簾___ tʂ^{h}wɑŋ lijɪn	25.mouth/嘴巴___ ʦwei pɑ	35. shorts (pants)/ 短褲 ___ tuwɑn k^{h}u
6. television/電視___ tijɛn ʂɨ	16.swim/游泳___ joʊ jɑŋ	26.tomato/番茄___ fɑn tɕ^{h}ijɛ	36. crutch/拐杖___ kwɑi tʂɑŋ
7. barbecue/烤肉___ k^{h}ɑʊ ʐo	17.telescope/望遠鏡 ___ wɑŋ yɛn tɕiŋ	27. Ferris wheel/摩天輪 ___ mΩ t^{h}ijɛn luwən	37.pizza/披薩___ p^{h}i sɑ
8.milk/牛奶___ nijou nɑi	18.banana/香蕉___ ɕjɑŋ ʨjɑʊ	28.shrimp/蝦子___ ɕjɑ tsɨ	38.strawberry/草莓___ ts^{h}ɑu mei
9.boy/男生___ nɑn ʂʌŋ	19. apple/蘋果____ p^{h}iŋ kwΩ	29.tooth/牙齒___ jɑ tʂ^{h}ɨ	39. pineapple/鳳梨 _____ foŋ li
10.basketball/籃球___ lɑn tɕ^{h}o	20. dinosaur/恐龍___ k^{h}oŋ loŋ	30.turtle/烏龜 _____ u kwei	40.sun/太陽___ t^{h}ɑi jʌŋ

APPENDIX E

QUESTIONNAIRE

親愛的家長:

感謝您參與本研究。請您協助填寫兒童基本資料及相關資訊。資料將予以保密，敬請放心!

兒童基本資料表

姓名: ________________________ 出生日期: ________________

主要照顧者: ___________________ 與兒童關係: ______________

填表日期: _____________________ 地點: ___________________

是 否

☐ ☐ 1. 您的小孩有醫療診斷嗎? ______________________

☐ ☐ 2. 您的小孩有聽力檢查報告嗎?

☐ ☐ 3. 您的小孩曾罹患耳朵感染的相關及病嗎? 如果有的話，多少次? _____ 次。

☐ ☐ 4. 你的小孩耳部是否放置耳管? ☐ 目前正置放耳管請打✓。

☐ ☐ 5. 請問您及家人會聽不懂孩子的語音表達嗎?

☐ ☐ 6. 請問家人以外的人會聽不懂您孩子的語音表達嗎?

☐ ☐ 7. 您的小孩有任何發展上的問題嗎?(如: 一歲後還只能爬行；18 個月大後才開始會走)。

☐ ☐ 8. 您的小孩有任何語言發展上的問題嗎? (如:一歲時還沒有發出聲音；一歲後才開始說第一個字；晚說話的兒童)

☐ ☐ 9. 您的孩子曾接受語言治療嗎?

APPENDIX F

MANDARIN ASSESSMENT OF PHONOLOGICAL PATTERNS ANALYSIS FORM

Name_______________________________ Examiner___________________________ Date_____________________

IPA Transcriptions		WORD/SYLLABLE STRUCTURES				CONSONANT CATEGORY DEFICIENCIES					
		Syllable Omissions	Consonant Omissions			Sonorants			Obstruents		
			Sequences	Pre-vocalic	Post-vocalic	Liquids	Nasals	Glides	Stridents	Posterior *fronting /p, p^h, t.t^h/only	Other *backing /k, k^h/only
Target Words	Productions										
1.piŋ tɕ^{h}i lin			ŋtɕ^h	p l	n	l	ŋ n		tɕ^h		p
2.p^{h}u t^{h}ɑʊ				p^h t^h							p^h t^h
3.mɪjɛn tɕy			ntɕ	m j			m n	j	tɕ		
4.mɑʊ ɕoŋ				m ɕ	ŋ		m ŋ		ɕ		
5.fei p^{h}ɑn				f p^h	n		n		f		p^h
6.tijɛn ʂɨ				t j			n	j	ʂ		t
7.k^{h}ɑʊ ʐo				k^h ʐ					ʐ	k^h	
8.nijou nɑi				n j n			n n	j			
9.nɑn ʂʌŋ			nʂ	n	ŋ		n n ŋ		ʂ		
10.lɑn tɕ^{h}o			ntɕ^h	l		l	n		tɕ^h		
11.lijo hwɑ t^{h}i			hw	l j t^h		l		j w			t^h
12.kɑʊ li ʦ^{h}ɑi				k l ʦ^h		l			ʦ^h	k	
13.k^{h}ɑ tʂ^{h}ɣ				k^h tʂ^h					tʂ^h	k^h	
14.hoŋ ly tʌŋ			ŋl	h t	ŋ	l	ŋ ŋ				t
15.tʂ^{n}wɑŋ lijɪn			tʂ^{h}w ŋl	j	n	l	ŋ n	w j	tʂ^h		
16.joʊ jɑŋ				j j	ŋ		ŋ	j j			
17.wɑŋ yɛn tɕiŋ			ntɕ	w tɕ	ŋ n ŋ		ŋ n ŋ	w	tɕ		
18.ɕjɑŋ ʨijɑʊ			ɕj ŋʨ	j			ŋ	j j	ɕ ʨ		
19.p^{h}iŋ kwΩ			ŋkw	p^h			ŋ	w		k	p^h
20.k^{n}oŋ loŋ			ŋl	k^h	ŋ	l	ŋ ŋ			k^h	
	Subtotal										

IPA Transcriptions		WORD/SYLLABLE STRUCTURES				CONSONANT CATEGORY DEFICIENCIES					
		Syllable Omissions	Consonant Omissions			Sonorant			Obstruent		
Target Words	Productions		Sequences	Pre-vocalic	Post-vocalic	Liquids	Nasals	Glides	Stridents	Posterior *backing /k, kʰ/only	Other *backing /k,g,h/
21. ɕyɛ ʐʌn				ɕ ʐ	n		n		ɕ ʐ		
22.ʂoʊ tʂɨ				ʂ tʂ					ʂ tʂ		
23. soŋ ʂu			ŋʂ	s			ŋ		s ʂ		
24.ʐɤ koʊ				ʐ k					ʐ	k	
25.ʦwei pɑ			ʦw	p				w	ʦ		p
26. fɑn tɕʰijɛ			ntɕʰ	f j			n	j	f tɕʰ		
27.mɷ tʰijɛn luwən			nl	m tʰ j w	n	l	m n n	j w			tʰ
28. ɕijɑ tsɨ				ɕ j ts				j	ɕ ts		
29.jɑ tʂʰɨ				j tʂʰ				j	tʂʰ		
30.u kwei			kw					w		k	
31.y sɑn				s	n		n		s		
32. ɝ tuwɷ				t w				w			t
33. pɑi yn				p	n		n				p
34. kʰɤ lɤ				kʰ l		l				kʰ	
35. tuwɑn kʰu				t w kʰ	n		n	w		kʰ	t
36. kuwɑi tʂɑŋ				k w tʂ	ŋ		ŋ	w	tʂ	k	
37. pʰi sɑ				pʰ s					s		pʰ
38. tsʰɑu mei				tsʰ m			m		tsʰ		
39. foŋ li				f l	ŋ	l	ŋ		f		
40. tʰɑi jʌŋ				tʰ j	ŋ		ŋ	j			tʰ
	Subtotal		18	76	19	10	39	24	32	10	15
	Total Deviations										

APPENDIX G

Substitutions and Other Strategies Analysis Form

	1. Stopping	2. Glottal Stop Replacement	3. Fronting	4. Backing	5. Gliding	6. Vowelization	7. Metathesis	8. Migration	9. Aspiration	10. Deaspiration	11. Affrication	12. Deaffrication	13. Palatalization	14. Depalatalization	15. Labial Assimilation	16. Nasal Assimilation	17. Velar Assimilation	18. Other Assimilations	19. Coalescence	20. Reduplication	21. Vowel Deviations	22. Diphthong Reduction	23. Epenthesis	24. Other Additions	25. Frontal Lisp	26. Lateral Lisp	27. Other sibilant Distortions	28. Other Deviations and Preferences
1.piŋ tɕ^{h}i lin																												
2.p^{h}u t^{h}ɑu																												
3.mijæn tɕy																												
4.mɑu ɕyoŋ																												
5.fei p^{h}an																												
6.tijæn ʂɨ																												
7. k^{h}ɑu ʐou																												
8. nijou nai																												
9.nan ʂəŋ																												
10.lan tɕ^{h}ijou																												
11.lijou huwa t^{h}i																												
12.kɑu li ʦ^{h}ai																												
13.k^{h}a tʂ^{h}ɣ																												
14. hoŋ ly təŋ																												
15. tʂ^{h}waŋ lijæn																												
16. jou yoŋ																												
17. waŋ yɛn tɕiŋ																												
18.ɕijɑŋ tɕijɑu																												
19. p^{h}iŋ kwΩ																												
20. k^{h}oŋ loŋ																												
Subtotal																												

	1. Deaspiration	2. Aspiration	3. Glottal Stop Replacement	4. Stopping	5. Fronting	6. Backing	7. Gliding	8. Vowelization	9. Metathesis	10. Migration	11. Affrication	12. Deaffrication	13. Palatalization	14. Depalatalization	15. Labial Assimilation	16. Nasal Assimilation	17. Velar Assimilation	18. Other Assimilations	19. Coalescence	20. Reduplication	21. Vowel Deviations	22. Diphthong Reduction	23. Epenthesis	24. Other Additions	25. Frontal Lisp	26. Lateral Lisp	27. Other sibilant Distortions	28. Other Deviations and Preferences
21. ɕyɛ ʐən																												
22.ʂou tʂɨ																												
23. soŋ ʂu																												
24.ʐɣ kou																												
25.ʦwei pa																												
26. fan ts^{h}ijɛ																												
27. mΩ t^{h}ijæn luwən																												
28. ɕija tsɨ																												
29.ja tʂ^{h}ɨ																												
30. wu kwei																												
31.y san																												
32. ɝ twΩ																												
33. pai yin																												
34. k^{h}ɣ lɣ																												
35. twan k^{h}u																												
36. kwai tʂaŋ																												
37. p^{h}i sa																												
38. ts^{h}ɑu mei																												
39. foŋ li																												
40. t^{h}ai jaŋ																												
Subtotal																												
Totals																												

APPENDIX H
Receptive and Expressive Vocabulary Test –II Record Form

88173

華語兒童理解與表達詞彙測驗紀錄本

Receptive and Expressive Vocabulary Test (REVT)

黃瑞珍、簡欣瑜、朱麗璇、盧璐 編製

00011-09

第一部分：基本資料

姓名		地區	縣 市 鄉鎮	年齡計算			
性別	☐男 ☐女	就讀學校		施測日期	年	月	日
轉介者	☐家長 ☐老師	施測人員		出生日期	年	月	日
轉介理由		施測地點	☐早療中心 ☐醫院 ☐家中 ☐學校	實足年齡	歲	月	日

第二部分：分測驗標準分數與百分等級

分測驗	理解量表原始分數	表達量表原始分數	分測驗原始總分	標準分數 (1-19)	百分等級
命名			／48		
歸類			／95		
定義			／59		
推理			／30		
合計	(1)	(2)	(3)		

第三部分：量表、全測驗標準分數與百分等級

量表	原始分數	標準分數	百分等級
理解量表	(1)		
表達量表	(2)		
全測驗	(3)		

心理出版社

第四部分：施測過程兒童行為觀察

施測過程兒童行為有異常者打 ˅

☐分心 ☐過動 ☐緊張 ☐膽怯 ☐注意細節 ☐被動 ☐固著性

施測過程兒童言語及溝通行為有異常者打 ˅

☐構音 ☐音質 ☐音量 ☐音調 ☐節律

☐語意不明確 ☐語句過於簡短 ☐語法錯誤

☐起始話題困難 ☐維持話題困難 ☐輪替困難 ☐語言互動困難

第五部分：施測結果能力描述

分測驗	標準分數	能力不足 1-3	低下 4-5	中下 6-7	中等普通 8-12	中上 13-14	優秀 15-16	非常優秀 17-19
命名		☐	☐	☐	☐	☐	☐	☐
歸類		☐	☐	☐	☐	☐	☐	☐
定義		☐	☐	☐	☐	☐	☐	☐
推理		☐	☐	☐	☐	☐	☐	☐

量表	標準分數	能力不足 ≦69	低下 70-79	中下 80-89	中等普通 90-109	中上 110-119	優秀 120-129	非常優秀 ≧130
理解量表		☐	☐	☐	☐	☐	☐	☐
表達量表		☐	☐	☐	☐	☐	☐	☐
全測驗		☐	☐	☐	☐	☐	☐	☐